FINAL DRAFT

LAKE COCHITUATE
LONG TERM VEGETATION MANAGEMENT PLAN

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INTRODUCTION

Lake Cochituate is a 614-acre lake that is divided into three distinct basins – North Pond, Middle Pond and South Pond – and is located in the towns of Natick, Framingham and Wayland (Figure 1). The lake is an important freshwater recreational resource for the greater Boston area. There is intensive lake use for boating, swimming and fishing due to the presence of Cochituate State Park (CSP) , other municipal access points and the heavily developed shorelines. The lake is owned and managed by the state through the Department of Conservation and Recreation (DCR), formerly the Department of Environmental Management (DEM). After documenting an infestation of non-native and invasive milfoils (*Myriophyllum spicatum* and *M. heterophyllum*) in South Pond and Middle Pond in 2002, steps were taken to prevent additional spread. Fragment barriers were installed across the channels that connect the main basins to capture milfoil fragments and prevent them from flowing from South Pond into Middle and North Pond, which is the direction of water flow. In addition to capturing milfoil fragments, the barriers prevented boat passage between the lake basins and the inadvertent transfer of plant fragments on boats. Despite deployment of these barriers, the milfoil continued to spread to other portions of Middle Pond and into North Pond. DCR's Lakes and Ponds Program and CSP staff responded by formulating a two-stage project to deal with the milfoil infestation. The initial stage called for short-term containment and control of the non-native vegetation to help prevent any further spread from occurring. The second stage called for additional assessment and development of a Long-Term Vegetation Management Plan for the lake. A Request for Response for this project was released in February 2003 and was awarded to Aquatic Control Technology, Inc. (ACT) of Sutton, Massachusetts.

Recommended short-term control strategies included chemical treatment of an estimated 50-60 acres with EPA/State registered aquatic herbicides, installation of bottom weed barriers and use of diver hand pulling for widely scattered milfoil plants. Since the proposed chemical treatment areas were all in Natick, a Notice of Intent was filed with the Natick Conservation Commission in April 2003. The first public hearing was held on May 1, 2003. Concerns were raised over the proximity of the Town's Springvale well field located approximately 200 feet inland from the lake shore at the northern end of South Pond. The hearing was continued to May 15, 2003. Additional information was prepared and submitted to support the use of aquatic herbicides in specific portions of the lake's South Pond. The hearing was continued to May 29, 2003. After a 1000 foot no-treatment setback around the shore nearest the well field was agreed to, the Conservation Commission issued an Order of Conditions on June 5, 2003. The Department of Environmental Protection (DEP) also issued a License to Apply Chemicals for the proposed treatment. Subsequently, the Order of Conditions was appealed due to opposition to the use of chemicals. DEP scheduled and held a Site Visit on September 26, 2003 that was attended by the proponents and appellants of the project. On March 9, 2004, DEP issued a Superseding Order of Conditions that allowed the project to proceed by affirming the Natick Conservation Commission's Order of Conditions.

The MA Natural Heritage and Endangered Species Program (NHESP) reviewed the original Notice of Intent that called for herbicide treatment, benthic barriers and hand-pulling of milfoil at Lake Cochituate.

NHESP responded by stating, "it is our opinion that this project, as currently proposed, will not adversely affect the actual habitat of rare wildlife".

Since the appeal stopped all of the proposed management strategies at the lake, a second Notice of Intent application was filed in July 2003 seeking approval for the installation of bottom weed barriers, fragment barriers and diver hand pulling. An Order of Conditions was promptly issued for these tasks and work commenced in August 2003.

Despite the delays in implementing short-term milfoil control strategies, assessment of in-lake conditions continued throughout the summer and early fall of 2003. Detailed aquatic plant surveys were performed by ACT on June 12, 2003 and October 3, 2003 along with several more cursory inspections. Survey efforts completed in 2003 focused exclusively on the lake's aquatic plant community. Since other features and characteristics of a lake must be considered in order to develop a sound vegetation management plan, existing reports were consulted for information on lake morphometry and water quality. The balance of this report presents the 2003 survey findings and compares it to existing data. Management alternatives are evaluated followed by a recommended long-term vegetation management plan for Lake Cochituate.

REVIEW OF AVAILABLE DATA

Principal sources for the majority of background information reviewed for this project included the "Lake Cochituate Data and Summary Report, April 1976-August 1980" that was completed by the Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control in June 1982 and the "1994 Lake Cochituate Monitoring Report" completed by the DEM Lakes and Ponds Program in February 1995. A concise history of Lake Cochituate was found in the "Cochituate State Park, Callahan State Park Management Plan: Guidelines for Operations and Land Stewardship" prepared by DCR in June 2003. Watershed descriptions were found in the "Snake Brook Watershed Preliminary Dredging Feasibility and Nutrient Loading Evaluation" prepared by ENSR in 1998. Information from these documents is presented in the following sections to provide some brief background information on the lake.

HISTORY

Historical references to Lake Cochituate date back to at least the 18th century. The current lake configuration remains similar to the original conditions despite surrounding development and numerous changes within the lake over the years. In the mid-19th century, dams were constructed and the lake started to be used as a public water supply. This continued until 1930-31 when the lake was taken out of primary water supply use by the Metropolitan District Commission and relegated to reserve reservoir status. In 1947 jurisdiction over the lake transferred to what is presently known as the Department of Conservation and Recreation and the lake was designated for recreation. Cochituate State Park now reportedly sees 200,000 visitors annually that utilize the facilities and lake for various recreational activities.

Major developments that directly influenced the lake in the 1950's included the construction of the U.S. Army Natick Labs and the Massachusetts Turnpike. These changes coupled with increased development in the lake's extensive watershed led to excessive nutrient loading, resulting in algal blooms and occasional fish kills. Numerous studies and nutrient reduction efforts followed, including attempted aeration and de-stratification in the 1970's and the construction of a filter berm and two detention basins in the 1980's under the Clean Lakes Program. Contamination from the U.S. Army Natick Labs resulted in the formation of a Restoration Advisory Board that continues to work on assessment and remediation efforts.

LAKE CHARACTERISTICS

There are three distinct basins of Lake Cochituate; South Pond, Middle Pond that includes a separate smaller basin referred to as Small Pond and Carling Basin, and North Pond. These basins are oriented along a north-south axis, and water flows in a northerly direction from South Pond, through Middle Pond and out of the dam found on the western shoreline of North Pond. Some flow diversions have occurred over the years, most notably those following construction of the Massachusetts Turnpike. There were no specific references to a hydrologic budget in any of the existing reports that were reviewed for this project. The aeration and destratification study (Cortell 1973) did report a mean annual outflow rate of 22 cfs. Using the reported water volume for the lake, this translates into a rough retention time of 0.86 years and flushing rate of 1.15 times per year.

Detailed morphometric data on Lake Cochituate were presented in the 1982 DEQE report and DEM's 1994 Monitoring Report. The summary table below was adapted from DEM's 1994 Monitoring Report. The surface area of each basin was calculated by redrawing the shoreline from the color orthophoto quadrangles available from MassGIS.

Table 1 – Lake Cochituate Morphometric Data

Feature	South Pond	Carling Basin	Middle Pond	North Pond	Totals
Maximum Length	5083 feet	1198 feet	4625 feet	5868 feet	3.2 miles total
Maximum Width	2775 feet	599 feet	2035 feet	3189 feet	-
Maximum Depth	69 feet	30 feet	60 feet	69 feet	-
Mean Depth	19.9 feet	12.7 feet	27.7 feet	27.8 feet	22.0 feet mean
Area	246 acres	15 acres	153 acres	198 acres	612 acres total (614 ac previously reported)
Volume	4638.6 acre-feet	164.5 acre-feet	3620.3 acre-feet	5370.9 acre-feet	13,794 acre-feet total
Shoreline Length	4.5 miles	0.8 miles	4.2 miles	3.6 miles	13.1 miles total

Bathymetric maps with 10 foot contour lines were prepared by the Lake Cochituate Watershed Association for the 1982 DEQE report. These maps appear to be fairly representative of current conditions based on observations made during the 2003 survey work. The bathymetry of South Pond was further verified during the aquifer study conducted by the USGS in 2001 (Friesz and Church 2001), which used an echosounder to map bathymetry and the thickness of fine-grained sediments. Bathymetric contours were again reported in 10-foot intervals and the contour lines closely matched those reported in 1980. The basins are generally characterized by fairly steeply sloped shorelines and relatively small littoral zones. Major exceptions to this include Pegan Cove and adjacent areas on South Pond and coves at the north end of Middle Pond where Snake Brook joins the lake.

WATERSHED

Lake Cochituate has a reported watershed area that is 17 square miles. Six major sub-basins have been delineated. The two largest sub-basins, Beaverdam Brook and Course Brook, flow through Fisk Pond before flowing underneath Route 135 and into South Pond. The Pegan Brook sub-basin flows into the eastern side of Pegan Cove. The other notable sub-basin is Snake Brook that empties into the northern cove of Middle Pond that lies between the Route 30 and Mass Pike bridges.

Numerous studies have been performed on the watershed over the years, particularly on Beaverdam Brook and Snake Brook which have been identified as major nutrient contributors. Most of the watershed supports moderate to heavy development, and non-point source pollution is undoubtedly significant. DCR applied for and was awarded a section 319 grant to reduce the pollution entering the lake via Snake Brook; work is currently under way.

WATER QUALITY

Previous water quality investigations determined that Cochituate is a phosphorus limited lake, with N:P ratios in excess of 25:1. Still both phosphorus and nitrogen loading appears to be considerable. In-lake phosphorus concentrations in surface waters generally ranged between 20-50 µg/l in the 1982 DEQE report and were reported to be 30-50 µg/l by DEM in 1995. Phosphorus concentrations in excess of 20 µg/l are generally considered to be sufficient to stimulate algal blooms. Internal loading may also be considerable as much higher phosphorus concentrations have been reported in the anoxic hypoliminion waters when the lake is thermally stratified during the summer months. There appears to be more fluctuation in the in-lake nitrogen concentrations.

The pH readings appear to trend slightly basic (between 7-8) in the surface waters. This is probably attributable to high algal densities that consume carbon dioxide and cause a rise in pH. There is a drop in pH with depth, but most reported values are above 6 and well within normal ranges for the region. Alkalinity values ranged between 20 and 50 mg/l in 1994, which is slightly higher than values that were reported in the 1982 DEQE study. The lake is moderately to well buffered against acid additions as compared to many other water bodies in the region. Specific conductance readings also appeared to have increased between the 1982 and 1995 reports. This is probably representative of increased mineral content or ions in the water.

Temperature and dissolved oxygen profiling performed in 1994 produced similar results in all three major basins. A thermocline was generally encountered between 5 and 6 meters. Dissolved oxygen concentrations were near saturation in the epilimnion, while the hypolimnion waters were anoxic.

There appears to be seasonal variability in Secchi disk water clarity and differences between the basins during each sampling event. The 1982 DEQE report provided readings for each basin for the four year period between 1976 and 1979. The average value in South Pond was 1.2 meters, while Middle and North Pond both averaged 1.9 meters. DEM's 1995 report provided readings from a single survey in the middle of August. South Pond was 1.7 meters, Middle Pond was 1.9 meters and North Pond was 4.0 meters. Secchi disk readings were taken during the 2003 vegetation surveys. On June 12, 2003, the Secchi disk clarity in South Pond was 1.9 meters and Middle Pond was 2.0 meters. North Pond only measured 1.3 meters on October 3, 2003. Reduced clarity measurements are primarily due to regular algal blooms that occur primarily during the late summer and fall months.

PHYTOPLANKTON

Lake Cochituate is a biologically productive lake, and free-floating algal densities are typically elevated due to the ample nutrient availability. Extensive phytoplankton monitoring was reported in the 1982 DEQE report. Several different taxa of diatoms, green algae and blue-green algae were found. Normal seasonal algal succession patterns were evident, especially with the diatoms that generally favor cooler water and the blue-green algae that often peak during late summer and at the spring and fall turnover events. Green algae appeared to maintain the most consistent densities in all basins. Shifts in algal dominance have likely occurred over the years, especially as nutrient loading from the watershed has changed.

FISHERY

The fishery in Lake Cochituate is reported to be diverse, with variability between the basins (DEM 1995). Numerous warm water species are present including large and smallmouth bass, chain pickerel, yellow and white perch, bluegill and other common species. The Division of Fisheries and Wildlife has also routinely stocked the lake with rainbow and brown trout, along with occasional stocking of Atlantic salmon brood stock. Stockings of northern pike and tiger muskies have also occurred in the past.

RARE AND ENDANGERED SPECIES

The only known rare species in the lake is the Boreal turret snail (*Valvata sincera).* This is one of three known populations in the state, the other two are found in the Berkshires. It is believed to be at the southern end of its range in Massachusetts (DCR 2003).

AQUATIC VEGETATION SURVEY - 2003

Documenting the aquatic plant community to evaluate non-native and nuisance plant management alternatives was the primary impetus for this study. Survey efforts during the 2003 season focused exclusively on determining the extent of the non-native Eurasian and variable watermilfoil coverage and documenting other aquatic macrophytes in the lake. The aquatic plant community was documented in previous surveys, but was never listed as being problematic or mentioned as requiring management. Methods of dealing with the frequent algal blooms have dominated previous discussions of in-lake management. The 1982 DEQE report stated "[a]quatic macrophytes are not considered to be a major problem at Lake Cochituate."

Aquatic plant growth has undoubtedly been restricted by the limited littoral zone and steeply sloped shorelines that are found around much of the lake. Limited light penetration due to high algal densities and unsuitable substrate were also listed as factors that limit vascular plant growth at the lake (DEQE 1982).

Two comprehensive vegetation survey efforts were performed at the lake in 2003. The first survey was performed in June and focused on South Pond and portions of Middle Pond to gather information for the permit applications that were submitted for milfoil management activities proposed for the lake that summer. Another comprehensive survey that covered the remainder of Middle Pond and North Pond was completed in early October of 2003.

The systematic vegetation survey methods used at the lake are described below followed by a narrative description of the aquatic plant community and comparisons to previous reports.

VEGETATION SURVEY METHODS

Each basin in the lake was systematically toured by boat. A comprehensive transect and data point sampling methodology was used to gather qualitative and quantitative information on existing conditions in the lake. Transects were randomly spaced along the shoreline and generally ran from shore towards the middle of the lake and extended throughout the littoral zone or extent of plant growth. Usually 2-5 data points were sampled along each transect. The location of each data point was geo-referenced using a Differential GPS system equipped with sub-meter accuracy. This information was transferred into a GIS software application providing for accurate mapping. Transect and data point locations are depicted in Figures 2, 3 and 4 found that are found in Appendix A.

At each data point the following information was recorded: water depth, sediment type when notable, aquatic plants present in decreasing order of abundance, total plant cover, milfoil cover and plant biomass. Water depth and sediment probing was conducted with a calibrated sounding rod. A fish-finder sonar unit was also used. The plant community was assessed through visual inspection, use of a long-handled rake and throw-rake, and with an Aqua-Vu underwater camera system. Plants were identified to genus and species where possible. Plant cover was given a percentage rank based on the areal coverage of plants within an approximate 400 square foot area assessed at each data point. Generally, in areas with 100 percent cover, bottom sediments could not be seen through the vegetation. Percentages less than 100 percent indicated the amount of bottom area covered by plant growth. The presence and dominance of Eurasian and variable watermilfoil, the two dominant non-native plants, were also recorded at each data point. In addition to cover percentage, a plant biomass index was assigned at each data point to document the amount of plant growth vertically through the water column. Plant biomass was estimated on a scale of 0-4, as follows:

- 0 No biomass; plants generally absent
- 1 Low biomass; plants growing only as a low layer on the sediment
- 2 Moderate biomass; plants protruding well into the water column but generally not reaching the water surface
- 3 High biomass; plants filling enough of the water column and/or covering enough of the water surface to be considered a possible recreational nuisance or habitat impairment
- 4 Extremely high biomass; water column filled and/or surface completely covered, obvious nuisance conditions and habitat impairment severe

Information recorded at each data point is provided in the Field Survey Data Table found in Appendix B.

VEGETATION SURVEY FINDINGS

Submersed and floating leafed species were the focus of the field survey efforts because these types of plants were predominant and they inhabit areas that are potentially subject to milfoil infestation. Emergent species found along the shoreline were occasionally noted. The 19 different macrophytes that were encountered in Lake Cochituate during the 2003 surveys are listed in Table 2 below.

Table 2 – Aquatic Vegetation Encountered in Lake Cochituate

Macrophyte Species	Common Name	Abbreviation[1]	Type
Ceratophyllum demersum	Coontail	Cd	Submersed
Elodea canadensis	Elodea	Ec	Submersed
Filamentous algae		Fa	greens & blue-greens
Myriophyllum heterophyllum	Variable watermilfoil	Mh (Exotic)	Submersed
Myriophyllum spicatum	Eurasian watermilfoil	Ms (Exotic)	Submersed
Najas flexilis	Slender Naiad	Na	submersed
Nitella sp.	Stonewort	Ni	submersed
Nuphar variegatum	Yellow Waterlily	Nu	floating-leafed
Nymphaea odorata	White Waterlily	Ny	floating-leafed
Pontederia cordata	Pickerelweed	Pl	emergent
Potamogeton crispus	Curlyleaf pondweed	Pc (Exotic)	submersed
Potamogeton gramineus	Variable-leaf pondweed	Pg	submersed
Potamogeton perfoliatus	Clasping-leaf pondweed	Pp	submersed
Potamogeton pusillus	Thin-leaf pondweed	Pt	submersed
Potamogeton richardsoni	Richarsons pondweed	Ph	submersed
Potamogeton robbinsii	Robbins Pondweed	Pr	submersed
Sagittaria teres	Arrowhead	Sa	submersed
Utricularia sp.	Bladderwort	U	submersed
Valisneria americana	Wild Celery	V	submersed
Wolffia sp.	Watermeal	Wo	floating

Milfoil Coverage

The milfoil distribution was mapped separately for each basin. Eurasian watermilfoil had the widest distribution, while variable watermilfoil was confined to a few locations in South and Middle Ponds. Where milfoil plants were generally approaching the water surface when encountered, maps depict the estimated percentage of areal milfoil cover. The majority of milfoil was found in water depths ranging between 3 and 9 feet, but milfoil was found at reduced densities in 12 feet of water.

South Pond

South Pond supported the most extensive milfoil cover (Figure 5). Varying densities of milfoil cover were found in approximately 26 percent of this 246-acre basin. Milfoil represented 44 percent of the total plant cover in the littoral zone of South Pond. The most abundant coverage was found in Pegan Cove. Milfoil cover was between 50-75 percent throughout the majority of the cove. Exceptions included a small section at the northern end of the cove with greater than 75 percent milfoil cover, and in a narrow band towards the south-center of the cove where milfoil coverage dropped to 25-50 percent. Lower milfoil densities were found in the remainder of South Pond. Milfoil cover was generally between 10-25 percent along both shorelines in the southern two-thirds of South Pond. Somewhat denser patches were found in the shallow cove areas along both shorelines. The milfoil coverage dropped off in the northern third of the lake except for the northernmost shoreline near the junction with Carling Basin. Variable watermilfoil

[1] Plant species abbreviation used in transect/data point survey data tables in Appendix B.

was encountered in the northwest corner, along the southern shoreline near Pegan Cove and in the small cove that lies just north of Pegan Cove.

Middle Pond

The milfoil coverage in Middle Pond (Figure 6) was more extensive than originally estimated by DCR and Aquatic Control in 2002. Approximately 12 percent of this 168-acre basin (including Carling Basin) supported milfoil growth, and milfoil represented 18 percent of the total plant cover. Low density patches with less than 10 percent and 10-25 percent milfoil cover were found in Carling Basin and along the southern shoreline of Middle Pond. Low density patches were scattered along the eastern and western shorelines. The most extensive milfoil cover in Middle Pond was found in the shallow cove east of the Boat Ramp and in the northern cove that is divided by the Route 30 and Mass Pike bridges. Milfoil coverage was less than 10 percent in these areas during the June survey, but had increased up to 25-50 percent in some areas by October. One dense patch (approximately 1000 square feet) with greater than 75 percent cover was found at the eastern edge of the Boat Ramp. Milfoil growth did not extend far into the Snake Brook cove. The only site where variable watermilfoil was found was in the small cove near the connection to Carling Basin.

North Pond

The discovery of milfoil in North Pond (Figure 7) was disheartening. No milfoil was found in North Pond in 2002, so fragment nets were installed at the Mass Pike bridge to help capture fragments. Based on the limited distribution of milfoil plants at the southern end of North Pond, it appears as if migrating fragments were the source of the infestation. Plants were widely scattered and often only a single plant was encountered. Coverage was all less than 10 percent and the total area where milfoil was found comprised less than two acres. Milfoil only represented approximately 8 percent of the total plant cover found in North Pond.

Dominant Vegetation Assemblages

Aside from the presence of milfoil, the aquatic plant communities are consistent with the findings of the 1982 DEQE report and the 1995 DEM report. Common names are used in the following sections, scientific names are provided in Table 2 on page 7. Plant cover and biomass estimates represent average values from the transect/data point survey (Appendix B), and Table 3 and Chart 1 show the plant cover by basin.

South Pond

Robbins pondweed continues to be the most prevalent species along the eastern and western shorelines of South Pond (Figure 8). There are also occasional patches of clasping-leaf pondweed. Secondary species that were routinely encountered in these locations included slender naiad, bladderwort, elodea and thin-leafed pondweed. The plant assemblage shifted in Pegan Cove. Eurasian watermilfoil was clearly dominant, while secondary species included bladderwort, curlyleaf pondweed, Robbins pondweed and elodea. Slender naiad was encountered along the northeast shoreline.

The total plant cover in the South Pond littoral zone was moderate (60 percent cover). Biomass was also fairly high (2.5 biomass index), with plants often growing at or just below the surface. The total area supporting plant growth on South Pond was estimated to be 76 acres or 31 percent of the 246-acre basin. Plant growth was found in water depth to 12 feet, but coverage dropped off considerably after 10 feet.

Robbins pondweed and curlyleaf pondweed were listed as the dominant plants in South Pond in the 1982 DEQE report. Slender naiad, clasping-leaf pondweed and elodea were also noted by DEM in 1995. The significant shift in plant coverage or biomass can probably be attributed to the abundant milfoil growth in and adjacent to Pegan Cove.

Middle Pond

Middle Pond (Figure 9) supported a slightly higher cover (67 percent cover) of native plants in the littoral zone, as compared to South Pond, but the overall biomass was lower (2.0 biomass index). There were also some shifts in dominant species. Robbins pondweed was again most regularly encountered, followed by wild celery, slender naiad and variable leaf pondweed along the steeply sloped shorelines. The shallow coves in the northeastern portion of Middle Pond were dominated by Robbins pondweed, coontail, filamentous algae and watermeal. Carling Basin had little plant growth, other than low-density patches of Eurasian watermilfoil and a few small patches of white waterlily.

Plant cover was generally common to abundant with moderate biomass. The total area covered with aquatic plants in Middle Pond was estimated to be 35 acres or 21 percent of this 168-acre basin. Plants were routinely found in 12-13 feet of water.

There is certainly greater plant diversity and increased coverage compared to what was reported in the 1982 DEQE report. Robbins pondweed and clasping-leaf pondweed were noted as the dominant species at that time. Increased plant coverage was noted in the 1995 DEM report.

North Pond

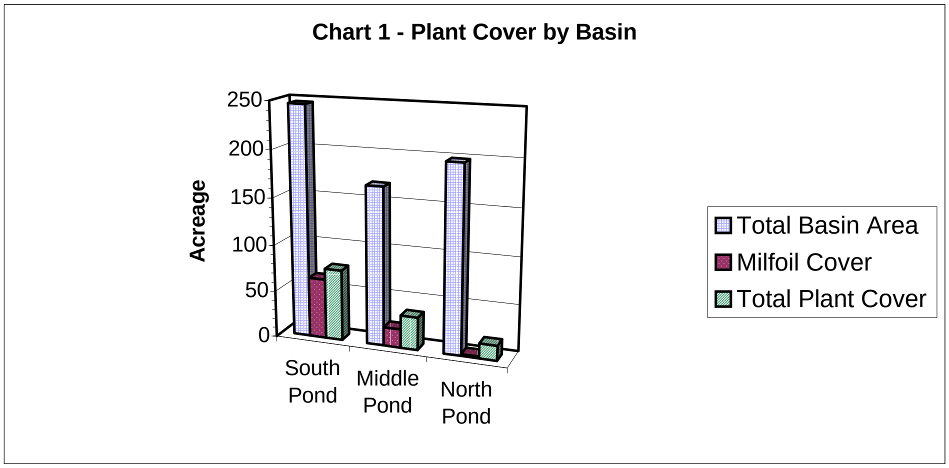
North Pond (Figure 10) supported the lowest densities (1.8 biomass index) and cover (52 percent cover) of aquatic plants within its littoral zone. Variable-leaf pondweed, Robbins pondweed, slender naiad, submersed arrowhead and wild celery were the dominant species encountered.

Plant coverage was generally scattered. The total area of plant cover was estimated at 16 acres, which is only 8 percent of this 198-acre basin. Plant growth generally dropped off after 10 feet.

Lower density plant growth in North Pond is consistent with previously reported findings. The species composition was also similar, being dominated by pondweeds, naiad and submersed arrowhead.

Table 3 – Aquatic Plant Coverage Data by Basin

Basin	Total Basin Area	Milfoil Cover	% of Basin Covered	Total Plant Cover	% of Basin Covered
South Pond	246 acres	64 acres	26%	76 acres	31%
Middle Pond & Carling Basin	168 acres	20 acres	12%	35 acres	21%
North Pond	198 acres	2 acres	1%	16 acres	8%



AQUATIC VEGETATION MANAGEMENT NEEDS AND OBJECTIVES

Before specific management objectives can be formulated, it is necessary to recognize historic and present lake uses. Present usage of Lake Cochituate is primarily focused on water-based recreation. Swimming and all forms of boating are regularly practiced, and Lake Cochituate is highly regarded as an excellent fishery. Less obvious than its recreational uses is the habitat that the lake provides for fish, other aquatic species and area wildlife. Portions of the lake serve to provide a significant portion of the recharge to Natick's municipal water supply wells, located just south of Route 9.

Management activities at Lake Cochituate must take all of these various uses into account and strive to enhance habitat and preserve water quality, while at the same time improving conditions for water based recreational uses. The most immediate threat to both the habitat and recreational activities on the lake is the recently established infestation of the aquatic invasive species of Eurasian and variable watermilfoil. DCR has initiated efforts to contain these plants and prevent further spread by installing fragment barriers across the channels that connect South Pond to Middle Pond and Middle Pond to North Pond. These barriers prevent boat travel between the lake basins and are greatly impacting usage for certain boating activities, especially waterskiing which is only permitted on South Pond. Benthic barriers were also installed in the summer of 2003 in the vicinity of the state beach on Middle Pond.

Nutrient loading from the lake's extensive watershed is considerable, but this has a more immediate effect on algal densities, and the lake has been plagued with algal blooms for decades. The previously noted work in the Snake Brook watershed is focused on addressing this issue. Nutrient reduction efforts are important for the long-term "health" of the lake, but it is widely accepted that watershed management will not significantly reduce invasive vascular plants like milfoil. Effective vegetation management will require in-lake strategies. Ultimately, a program that integrates both in-lake and watershed management strategies is recommended for the long-term preservation of Lake Cochituate.

Controlling the expanding milfoil infestation and preventing the establishment of other exotic plants is paramount to preserving the ecology and recreational opportunities at Lake Cochituate. The balance of this report is focused on the evaluation of in-lake management strategies to control non-native invasive aquatic vegetation. Available in-lake vegetation management techniques are reviewed for their applicability at Lake Cochituate. Some techniques are immediately dismissed due to environmental or legal constraints that are discussed. More comprehensive reviews of the more feasible techniques for Lake Cochituate are provided. These reviews culminate in a recommended Long-Term Vegetation Management Plan for Lake Cochituate. For a comprehensive review of available lake management techniques, readers are referred to the recently completed Generic Environmental Impact Report (GEIR), *Eutrophication and Aquatic Plant Management in Massachusetts* and the accompanying *The Practical Guide to Lake and Pond Management in Massachusetts.*

AQUATIC VEGETATION MANAGEMENT OPTIONS

The management alternatives discussed below were evaluated to a large extent based on findings of the GEIR.

NUTRIENT REDUCTION VIA WATERSHED AND SHORELINE MANAGEMENT

Watershed and shoreline management strategies will have little effect over time in reducing existing populations of aquatic invasive plants or retarding their further spread throughout the lake, as rooted invasive plants like watermilfoil, obtain the bulk of their nutrients from the in-lake sediments. In the vast majority of lakes, the sediment nutrient reserves alone are sufficient to sustain luxuriant growth for many decades to come even where external (watershed) inputs of nutrients entering the lake are relatively low. An aggressive and sustained program of in-lake vegetation management techniques will need to be implemented at Lake Cochituate in order to successfully remove or control the target plants. Watershed management, however, is important to further reduce nutrient so as to limit the magnitude and frequency of nuisance algal blooms. It is beyond the scope of this assessment and report for Lake Cochituate to identify the priority sources/origins of nutrients entering and the specific actions required to reduce this nutrient loading, and therefore, this report focuses on in-lake management techniques.

PUBLIC EDUCATION

Continually educating the public, particularly boaters and lake residents, about the threats posed by non-native and invasive aquatic plants may help prevent the introduction of new species and possibly limit the further spread of species like Eurasian watermilfoil to other non-infested water bodies in the region. The reality is that public education campaigns are largely preventative measures. Now that milfoil is established in all basins of the lake, further spread will likely occur despite public awareness. Nevertheless, public education efforts must continue.

The Department of Conservation and Recreation Lakes and Ponds Program has implemented a long-term educational program for the day users of the Lake as well as the abutters. In the summer of 2003, Lakes and Ponds Program staff hosted a Weed Watcher training course for local citizens. . The group was taught to identify the lake’s native and non-native invasive plants that are present in the lake. They also received a brief introduction to the state approved Standard Operating Procedures used for handpulling and benthic matting. One goal of this effort is that after these and other volunteers are trained, they can obtain approval from their conservation commissions to begin hand pulling the known infestations of weeds in small areas in North Pond and other areas.

For the summer season of 2004, DCR Lakes and Ponds Program staff plan to address both the in-lake issue of plants along with the possibility of new introductions. To reduce the possibility of new introductions, DCR has arranged to hire a trained ramp monitor to be present on high use days (Friday through Sunday and on certain holidays). The individual will be trained by DCR and will that will handout information, monitor boat trailers for the presence of aquatic plants, and will request participation and assist visitors in filling out a boater survey. Along with the additional staff, Lakes and Ponds staff plans to host two more Weed Watcher programs for the lake abutters and other interested citizens. An actual demonstration of the hand pulling techniques may also be done in June or July.

The agency's long-term education effort will include:

1. Hiring boat ramp monitors seasonally, when budgets permit;
2. Implementing an ongoing educational and outreach program to inform and involve the three Conservation Commissions and other municipal officials of the towns that surround the lake in the Department's ongoing efforts;
3. Working through the Cochituate State Park Advisory Committee and other groups as appropriate to continue monitoring the status of the lake's vegetation and related water quality parameters and continuing the discussion of management options with the abutters and other citizens who are interested in this project. Volunteer involvement with the lake is a key requirement to have the management plan be successful. Continual outreach efforts will be pursued through the Advisory Board and the DCR staff as needed.

MANUAL REMOVAL AND BENTHIC BARRIERS

Hand-pulling and suction harvesting (or hand pulling with suction removal) are the principal manual plant removal strategies used for submersed aquatic plant control. Benthic barrier installation is the only physical control strategy that is well suited for use at Lake Cochituate. All three of these approaches are generally used to control small localized patches of dense plant growth or widely scattered individual plants. This often limits their application to newly discovered, pioneer infestations or as follow-up to a larger scale management strategy such as chemical treatment or drawdown. It is usually ineffective and often counter-productive to apply these strategies to large-scale control efforts. As is true of most in-lake control strategies, there are advantages and limitations to each (see Table 4).

Table 4 - Comparison of Hand-Pulling, Suction Harvesting and Benthic Barriers

Approach	Typical Application	Advantages	Limitations	Approximate Unit Cost
Hand-Pulling	Widely scattered plants <500 stems per acre	- Highly selective - Can utilize trained volunteers in some cases	- Impractical for large areas with milfoil coverage greater than ~1-5%. - Reduced visibility from poor water clarity or suspended sediments from a mucky bottom	<$500 acre
Suction Harvesting	Small scattered to moderate infestations (< 1 acre in size)	- More efficient than hand pulling for higher plant densities	- Equipment difficult to relocate - Additional staff required - Increased turbidity - Very high cost	$5000 - $14,500 acre
Benthic Barriers	Small dense patches (< 0.25 acres)	- Quick control for small areas - Prevents reinfestation - Barriers can be reused	- Non-selective, kills all plants and may impact macroinvertebrates and other non-target organisms - Barriers require routine maintenance - Very high cost per acre	>$25,000 - $50,000 /acre

Hand-Pulling

Hand-pulling of submersed plants like milfoil usually involves dislodging plants from the bottom sediments and placing the entire plant in mesh collection bags. Care must be taken not to create plant fragments or allow them to escape. A person in a support boat is usually needed to empty the mesh collection bags and to collect plant fragments missed by the hand-pullers. The actual hand-pulling work can be accomplished by an individual equipped with a mask and snorkel in shallow water areas, typically less than 4-6 feet deep. This allows for trained volunteers to be utilized. In waters greater than 4-6 feet deep, SCUBA divers are required. Other factors that may complicate a hand-pulling effort include limited water clarity, highly flocculent or muddy or contaminated sediments that are easily suspended and reduce clarity, firm bottom substrate that prevents complete root removal, and dense cover of native species.

Several hand-pulling efforts have occurred in Massachusetts and other New England states in recent years. The ongoing hand-pulling program at Lake Dunmore in Salisbury, Vermont is generally considered to be an effective program. Milfoil was first found in this nearly 1000 acre lake in 1989. Immediate steps were taken by the Vermont Department of Environmental Conservation (VT DEC) and the lake association to contain and prevent further spread of this plant. Volunteer hand-pulling efforts were initiated in the first few years. Two full-time seasonal lake monitors were hired to oversee hand-pulling efforts in 1994; the number of employees has increased to five in recent years. Between 2000 and 2003, the Association reported 6000-8000 milfoil plants removed from the lake annually. This required the efforts of four full-time lake monitors and a considerable volunteer effort. The program has effectively prevented milfoil from spreading, but the program was initiated when the milfoil coverage and plant density was very low. Milfoil densities reported in the Association's annual reports were less than one plant per square yard. This is an extremely low milfoil density (less than 1 percent cover). (Lake Dunmore/Fern Lake Association Annual Reports 1994, 1998 & 2003).

Numerous hand-pulling efforts have been attempted on nearby Dudley Pond in Wayland in recent years. The most recent effort, in 2002, utilized 150 people (two support people per diver) to clear dense milfoil from two coves that were approximately an acre in size. Surveys performed after the effort suggested that a 35-40 percent removal was accomplished, but regrowth was fairly rapid (Draft GEIR 2003). Limiting factors were the turbidity generated during the operation and the number of fragments that remained on the bottom (Wagner 2003). Increased turbidity that reduces SCUBA diver visibility and removal efficiency along with risk to benthic organisms when disturbed sediments re-settle, were stated as reasons why hand-pulling is only appropriate for small infestations by VT DEC (VT DEC 2004).

Much of Lake Cochituate already has extensive milfoil coverage, especially in South Pond. The 2003 surveys found over 30 acres that contained more than 50 percent milfoil cover. The number of plants found in dense milfoil stands can be considerable. Dense milfoil stands that were monitored during a weevil (*Euhrychiopsis lecontei*) stocking effort on Saratoga Lake in New York had reported stem densities of more than 15 stems per square foot. This translates into over 650,000 stems per acre. It is impractical for hand-pulling to be utilized for removal of milfoil found at densities of even one stem per square foot (other than in very small areas) or over 40,000 plants per acre. Not only is the cost very high at these higher densities but it is a slow and labor intensive process that can prove to be counterproductive as disturbance of large areas of the lake bottom may well result in adverse effects to macroinvertebrates and fish habitat, along with a greatly increased potential for milfoil fragments to be created and spread. In addition, hand-pulling may not be suitable for the Pegan Cove portion of South Pond due to contaminants in the sediment that should not be disturbed.

At Lake Cochituate, hand-pulling is probably most applicable for low density milfoil growth (less than one percent) of less than 500 plants per acre (Wagner 2003). It may also be applicable for moderate density (less than 10 percent cover) in some of the smaller, localized patches. Cost will likely vary depending on milfoil density, area of infestation and staff being utilized. Previously reported cost ranges are generally less than $500 per acre for sparse (less than one percent) plant cover.

<u>Suction Harvesters</u>

Suction harvesters typically involve the use of a pump on a boat or barge and with two SCUBA divers to operate a pair of suction lines. Plants are dislodged from the sediment by hand, fed into the suction line and discharged into a mesh collection basket on the boat or barge. Suction harvesting essentially makes hand-harvesting more efficient. It is reportedly best suited for controlling just small areas with sparse to moderate growth that would require a considerable hand-pulling effort. Due to the potential turbidity generated with this technique, floating fragment barriers are sometimes used to isolate the area where the barge and divers are working to capture fragments. This limits the mobility of the unit, making it less efficient and substantially more costly to cover large areas with widely scattered plant growth. Typical suction harvesting operations require a crew of 3-4 personnel.

Suction harvesters have been constructed for milfoil control on several lakes in Vermont. Costs to build or purchase a barge and complete unit may range from approximately $10,000-$25,000. Operational costs exclusive of equipment purchases are usually reported to range between $5000 and $10,000 per acre. Operational costs were reported as $9000 per acre at Lake George, NY, while other lakes reported costs of $4000 per acre (Fugro/ACT 1995). Suction harvesting operations for hire are currently available in New York and Connecticut. Massachusetts's experience with this technique is fairly limited. Suction harvesting was attempted as a follow-up to the hand-pulling effort at Dudley Pond in 2002. A two-man crew reportedly cleared 500 square feet per hour with greater than 95 percent removal and limited regrowth after two months. There were issues with turbidity, capture of macroinvertebrates and fish and escaping fragments. Unit costs were calculated to be $14,500 per acre for this effort, but expected to drop to $10,000 per acre if a larger effort were undertaken. (GEIR 2004)

Aside from high unit costs and the amount of labor required, suction harvesting can present some non-target impacts. It is probably somewhat less selective than hand-pulling, especially after the turbidity increases as the operation gets underway. Other plants besides milfoil will inadvertently be harvested. Macro invertebrates either attached to plants or dislodged from the sediment during uprooting will be removed. The turbidity and suspended sediments produced using this approach is also more significant than hand-pulling (VT DEC 2004). Benthic organisms may be also smothered when the sediment settles-out. There is also a potential health and safety concern at South Pond should contaminated sediments be re-suspended in the water column. For these reasons, it is impractical for suction harvesting to be considered a suitable strategy for large-scale milfoil control efforts at Lake Cochituate. Use of this technique will likely be limited to control of moderate to dense infestations in small areas.

Benthic/Bottom Barriers

Several materials have been commercially manufactured to serve as benthic or bottom barriers in lakes. Typically, barriers are weighted to the lake bottom and kill plants through compression and blockage of sunlight. They are most effective for use in small areas around docks and swim areas. Large installations can become cost-prohibitive, with material costs exceeding $20,000 per acre, and may interfere with the utilization of bottom sediments by aquatic organisms. They are also non-selective, killing all plants that are covered and affecting macroinvertebrates as well. Plants are usually effectively controlled within 1-2 months of installation, so they could be moved to control plants in multiple locations within the same year. However, the labor required for installation and removal makes annual retrieval and redeployment more practical. Barriers must be routinely checked to insure that excess billowing/uplifting does not occur that could endanger swimmers or entangle boat props. Maintenance efforts and cost can be substantial, especially for larger installations. Observations at Lake Cochituate also indicate that fisherman can hook the net and damage it.

At present, commercially available materials include Palco, a solid PVC liner; Texel, a felt-like polyester material; and Aquascreen, a PVC coated fiberglass mesh. All three materials are negatively buoyant, but gases generated from decomposing plants underneath the barriers can cause billowing. Mesh is often preferred, especially where the sediments are of an organic nature. The aperture size of the Aquascreen mesh is small enough to effectively block sunlight, while still allowing gas transpiration to help limit billowing. Solid barriers usually provide longer duration plant control, but they are heavier, subject to billowing and more difficult to work with. The reduced weight of the mesh barriers helps ease installation and removal, but plants will eventually settle on top of the barriers and root through the mesh or in the sediment that accumulates on top of the barriers. Routine maintenance typically involves removal, cleaning and redeployment. This is usually required every 1-2 years with mesh barriers, and possibly less frequently with solid barrier depending on bottom sediments. Bottom barrier installations will likely be limited to small infestations of dense growth or in high use areas of the lake.

Approximately 7,350 square feet of Aquascreen were installed around the Cochituate State Park Beach on Middle Pond in August 2003. The barriers were installed around the outer edges of the swim area to control milfoil and dense native plant growth that was posing a potential swimming hazard. The material came in 7 foot x 100 foot panels and was weighted to the lake bottom using lengths of steel re-bar that was encased in PVC tubing. Purchase and installation costs were $1.65 per square foot. Maintenance costs to remove, repair and re-deploy the barriers in future years should be significantly lower. Benthic barriers may be considered for milfoil control in other portions of the lake where small dense patches are found. Considering the cost, labor and potential for off-target impacts, benthic barrier installations are probably limited to areas of less than 0.25 acres.

MECHANICAL REMOVAL

Several different approaches have been used to mechanically remove aquatic vegetation. The most commonly employed strategies in the northeast include dredging, harvesting and hydro-raking. Other mechanical techniques like rotovating/rototilling have been used on a limited basis elsewhere across the country with anecdotal if any demonstrated project experience in New England or MA.

Mechanical control of Eurasian watermilfoil is generally not recommended in water bodies like Cochituate where the distribution of milfoil is still confined to a limited portion of the lake's littoral zone. This approach is generally discouraged since it may result in further spread of milfoil that spreads primarily through vegetative fragmentation. Rotovating/rototilling the bottom sediments to destroy plant root structures and disrupt the substrate would also cause plant fragmentation and severe sedimentation and is not recommended at Cochituate given the likelihood of causing further spread of milfoil and significant disturbance of potentially contaminated sediments.

Dredging

Dredging involves the removal of bottom sediment to add water depth. It controls aquatic vegetation through physical removal of the plant and root structures and nutrient-rich sediments, and by leaving nutrient-poor sediments less suitable for plant growth. There can also be the added benefit of increasing water depth below the photic zone or the depth that light can penetrate to support plant growth. This can be accomplished by various means. Dry-dredging involves draining the lake and using conventional excavation equipment. Wet-dredging, performed without lowering the water levels, uses drag-line equipment from shore or excavation equipment on floating barges. Hydraulic or suction dredging involves the use of a floating barge equipped with an auger cutting head that pumps a slurry of sediment and water to nearby containment basins for dewatering. Dredging projects carry a high cost relative to other management techniques, and seldom is a cost-effective means of controlling rooted aquatic plants. Detailed planning and complicated, local, state and federal permits will also be required for most dredging projects. The permitting, data collection and planning process prior to implementation can take several years.

Dredging is not a suitable strategy for aquatic vegetation control at Lake Cochituate. Operationally, the lake is too large, without ample access sites to stage a major dredging operation. Deepening the shoreline littoral zone beyond the photic zone is also impractical. Milfoil was regularly found growing to 10 feet and even to 12 feet in some locations. Achieving sufficient depth to discourage milfoil growth would leave steeply sloped shorelines that would be subject to erosion, create difficult access for recreation and would drastically alter the existing fish spawning and wildlife habitat. Dredging areas to depths less than 10-12 feet would leave them subject for rapid recolonization by milfoil and other opportunistic exotic plants. Milfoil is often one of the first plants to become reestablished in disturbed sediments.

Even selective dredging in smaller areas would likely be cost-prohibitive. Typical unit costs range between $5-$25 per cubic yard for uncontaminated sediments that require no special handling or disposal. The location, limited access and other environmental issues would likely drive costs towards the upper end of the range. Deepening a 1-acre area by 1-foot may cost $20,000-$40,000 or more, exclusive of permitting and planning costs. The temporary disturbances that would result from a dredging operation would also be significant. Undoubtedly, a major obstacle to a dredging operation at Lake Cochituate would be the known sediment contamination in portions of South Pond. Dredging may not only uncover and redistribute contaminated sediment within the lake, but it might present additional safety concerns in locating and properly treating the dredge spoils that are removed from the lake. The permitting and actual dredging costs for the contaminated sediments in South Pond is expected to be cost prohibitive.

Harvesting

Cutting and collecting aquatic vegetation with specialized equipment is termed mechanical harvesting. Mechanical harvesters are barges propelled by paddle wheels and equipped with depth-adjustable cutting heads and conveyor-mesh storage areas. Plants are typically cut near the sediment and water interface, usually to a maximum depth of 7 feet. Once a full load is collected, the harvester travels to shore to off-load. Complimentary shore-conveyors and trailer conveyors are available to transfer the harvested material directly into dump trucks, or it can be stockpiled on shore to dewater before being loaded and hauled to a permanent disposal location.

With the exception of true annual plants that only propagate from seed, harvesting typically provides temporary control of aquatic plants. Some slower growing submersed plants such as largeleaf pondweed species are usually controlled for an entire summer season. However, many aquatic plants re-grow rapidly after being cut (much like cutting a lawn), necessitating two or more cuttings per summer to maintain open-water conditions. For example, the extensive rhizomes (root structures) of waterlilies are sometimes capable of sending new leaves to the surface within 2-3 weeks of cutting. Watermilfoil growth rates have been documented at more than one inch per day, which would result in rapid regrowth. Harvesting also presents a risk of spreading highly invasive species like Eurasian and variable watermilfoil that propagate through vegetative fragmentation. As a result, harvesting is not a recommended technique to control small or partial lake infestations of these plants. However, it is used in Massachusetts for control of milfoil in most cases where the water body is already heavily inundated with milfoil and harvesters owned or contracted by the municipalities or lake associations are operated throughout the summer months. At nearby Morses Pond and Lake Waban in Wellesley, both water bodies have employed mechanical harvesting for a period of years in their efforts to manage invasive milfoil and fanwort. Coincidentally, both the Town of Wellesley and Wellesley College, which oversee these two respective water bodies, are aggressively exploring other management techniques with a strong interest in the use of Sonar (active ingredient fluridone) herbicide.

Harvesting is not recommended for control of milfoil at Lake Cochituate. Presently, milfoil covers only a small percentage of Middle and North Ponds. Even in South Pond, there is considerable littoral area that remains clear of milfoil at the higher densities of greater than 50 percent cover. The risk of further spreading the infestation through escaping plant fragments outweighs the temporary level of control that might be achieved.

Hydro-Raking

Mechanical hydro-raking involves the removal of aquatic plants and their attached root structures. Hydro-rakes are best described as floating backhoes. The barge is powered by paddle wheels similar to a harvester, and it is equipped with a hydraulic arm that is fitted with a York Rake attachment. The rake tines dig through the bottom sediments, dislodging the plants in water depths up to approximately 12 ft. Many hydro-rakes do not have on-board storage, so each rake full needs to be deposited directly on-shore or else onto a separate transport barge. Plants with large, well-defined root structures like waterlilies and emergent species are most efficiently removed through hydro-raking. In some cases, control of these and similar species can be attained for 2-3 years or longer. This approach is also sometimes favored for annual weed maintenance of public beach and swim areas but is not a recommended approach for Cochituate.

Hydro-raking is not well suited for large-scale control of milfoil growth presently found in Cochituate. Removing some of the root structures may provide slightly longer-term control of the submersed milfoil growth, but there is probably an even greater risk of creating and spreading plant fragments that could worsen the infestation. Disturbance of potentially contaminated bottom sediments in South Pond is also likely to be a significant factor that does not favor this technique.

DRAWDOWN

Lowering water levels during the winter months to expose aquatic plants to freezing and desiccation (drying) is a commonly used management approach in northern climates. It can be a relatively low- or no-cost management strategy, provided that several key conditions are met. The target species must be susceptible to drawdown conditions, and both Eurasian watermilfoil and variable watermilfoil are positively controlled by drawdown. However, there are several potentially detrimental impacts associated with drawdowns. The principal complicating factors for a drawdown program at Lake Cochituate include:

- Inability to sufficiently lower the water level due to limitations of existing outlet control structure and shallow water depths in the channels underneath the bridges.
- Potential for negative impacts to the recharge rate of the adjacent Springvale well field.
- Potential exposure of contaminated bottom sediments, especially in South Pond.
- Interference with recreational use of the lake during the winter months.

Because of the characteristics of the Lake, and because the outlet structure is in North Pond, there is no conventional way to draw down the South and Middle Ponds alone, where the milfoil infestations are more severe. Similarly, isolating individual areas of those ponds is not a practically feasible alternative. Making modifications to the outlet structure and channels to permit a deep drawdown would require an extensive hydrologic and engineering study, numerous permits/approvals and would ultimately require a considerable financial investment. Impacts to the Town wells would require a similar level of investigation. Exposure of contaminated sediments would need to take into account the public's access to these areas during the period of drawdown and the potential movement of contaminated sediment through erosion and formation of gullies during the drawdown process. Recreational use of the lake would also be impacted if deep drawdowns were performed. Ice fishing would be directly impacted. Lower water levels may result in unsafe ice formation and may complicate gaining access to the ice.

Aside from these four major issues, there are practical considerations as to whether drawdown would be an effective strategy at the lake. In order for plant freezing and desiccation to occur, the bottom sediments must effectively dewater. Excessively mucky or peaty sediments prevent the necessary drying and freezing needed to destroy plant root structures. Most of the shoreline areas along Lake Cochituate have suitable soils for dewatering, but backwater cove areas such as Pegan Cove and the Snake Brook

Inlet on Middle Pond have considerable soft sediment/muck deposits. They would not likely dewater adequately, and presently support the most extensive milfoil cover found in the lake. The water level must be lowered sufficiently to expose problematic growth. Milfoil plants are generally found between 3-10 feet of water in the lake. Water depths reach 8 feet throughout much of Pegan Cove and adjacent areas with the highest density milfoil growth. A drawdown depth of at least 6 feet and probably 8 feet would be needed to provide any real benefit. Flow rates would need to be carefully calculated to determine if lowering and refill could occur within acceptable timeframes to limit impacts to aquatic species. Early refill would likely be required to facility early spring spawning of some game fish. Deep drawdowns could also cause reduced dissolved oxygen concentrations that could stress fish and other aquatic organisms. Other water quality changes may occur such as increased algae productivity.

Due to the host of potentially adverse impacts and regulatory constraints, drawdown is not likely to be a suitable strategy for inclusion in a long-term vegetation management plan at Lake Cochituate. If drawdown were to be further pursued at Lake Cochituate, a feasibility study will be needed to address the issues and potential concerns cited above, as well as the guidelines in the GEIR and the requirements of DEP's April 2004 Guidance Document for drawdown as it relates to aquatic plant management.

BIOLOGICAL CONTROLS

The introduction of herbivorous insects and fish is often considered to be a natural and potentially long-term management strategy to control excessive aquatic vegetation. Sterile or triploid grass carp (*Ctenopharyngidon idella*) that consume aquatic plants are regularly used as a management strategy in southern tier states, and have been used in a few New York and Connecticut water bodies. They reportedly do not show a feeding preference for milfoil. However, it is illegal to introduce grass carp into Massachusetts for any purpose; therefore the balance of this section will focus on discussion of herbaceous insects.

<u>Milfoil Weevil</u>

Most of the work with herbaceous aquatic insects in the region has focused on the control of Eurasian watermilfoil. A native aquatic weevil (*Euhrychiopsis lecontei*) that developed a preference for Eurasian watermilfoil over its native host species (*Myriophyllum sibiricum*) was first identified in Vermont after natural milfoil declines were observed in several lakes. The weevil generated a considerable amount of interest and study over the past decade. It is now being commercially reared and stocked as a milfoil control strategy. The weevil does not eradicate milfoil, but instead destroys apical meristems or growth points on the plant and reduces the buoyancy of the stems, causing the plants to collapse towards the bottom. A number of milfoil infested lakes in the northeast have attempted weevil stocking programs. Some significant milfoil reductions have been reported, but there have been oscillations between the milfoil and weevil densities, resulting in unpredictable levels of milfoil control. Limitations include availability of shoreline cover for overwintering weevils and fish predation. Additional studies are needed to determine whether or not weevil stocking can be an effective milfoil management strategy.

Most reported results suggest that results are quite variable. The best results have been reported from lakes that had an existing weevil population that was augmented through stocking programs. The Massachusetts experience with weevils is fairly limited. Two of the larger stocking efforts were performed at 31-acre Mansfield Lake in Great Barrington and 225-acre Goose Pond in Lee and Tyringham. Weevil damage was evident following both stocking programs. Mansfield Lake reported a milfoil crash in 2001, but recovery the following year. Goose Pond showed lower milfoil densities five years after stocking, but they were not directly attributed to weevil damage. The following year, milfoil densities were reportedly increasing again on Goose Pond. (GEIR 2004)

If weevils were responsible for reduced milfoil densities at Mansfield Lake and Goose Pond, they appear to be subject to the oscillations that would be expected in a predator-prey relationship. The resulting milfoil control is unpredictable and considered by many to be unacceptable for recreational uses. In fact Goose Pond is one of several northeastern lakes that have undergone extensive weevil stocking programs and are now pursuing the use of herbicides to achieve milfoil control. Other lakes that have foregone further weevil stockings in favor of herbicide or other management approaches include Long-Sought For Pond in Westford, MA; Quabog Pond in Brookfield, MA; Woodridge Lake in Goshen, CT; Twin Lakes in Salisbury, CT and Saratoga Lake in Saratoga, NY.

The State of Vermont has probably funded and researched more lakes with natural weevil populations and stocked or augmented populations than any state in the Northeast. They also have also been working with weevils the longest. In a recent finding they stated that, *"weevils have not yet proven to be effective in open water field settings where the insects have been intentionally introduced. No conclusive data is available at this time that documents that weevils can be used as a predictable and reliable watermilfoil control method"* (VT DEC 2004).

At this time, weevil introduction is not viewed as an effective lake-wide milfoil control technique for Lake Cochituate.

HERBICIDE TREATMENT

The use of chemicals to control nuisance aquatic plant and algae growth is probably the most widely used and recommended management strategy for lakes with milfoil infestations that are beyond effective control with non-chemical techniques like hand-pulling, suction harvesting or bottom barriers. Registered herbicides must meet strict federal guidelines and demonstrate that there is not an "unreasonable risk" to humans and the environment when applied in accordance with their product label. According to Madsen (June/July, 2000), *"currently no product can be labeled for aquatic use if it poses more than a one in a* *million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability or persistence in the environment*". Aquatic herbicides and algaecides are also subject to periodic re-registration with the Environmental Protection Agency (EPA), where the latest technology and scientific studies are used evaluate the potential impacts of these products. Most of the commonly used products have recently completed EPA's more stringent re-registration process. Aquatic herbicides and algaecides must also be registered for use in MA ponds and lakes by the Department of Agricultural Resources (DAR), Pesticides Board. In addition, chemical treatments in MA must obtain a site-specific License to Apply Chemicals from DEP's Office of Watershed Management and an Order of Conditions from the local Conservation Commission. Furthermore, most applications must be performed under the direct supervision of an Aquatic Applicator that is commercially certified and licensed in MA by the DAR.

When properly used, aquatic herbicides often provide area and species selective plant control, with less temporary disturbance than comparative mechanical or other non-chemical techniques. Herbicides are generally described as having either "contact action", meaning that only the actively growing portions of the plants that the chemical comes into contact with are controlled; or "systemic action", where the herbicide is internally translocated throughout the plant effectively killing the stem, foliage and root structures. The remainder of this section investigates the applicability of currently registered aquatic herbicides for use at Lake Cochituate

<u>Diquat (Reward)</u>

The principal contact-acting herbicides include diquat (Reward), endothall (Aquathol) and copper (various forms of copper-carbonate and copper-ethylenediamine complexes). These products target and disrupt different pathways, but are similar in that they only control portions of the plant that are directly contacted. Contact-acting herbicides are relatively fast acting, with most plant uptake usually occurring over a 1-3 day period. Susceptible plants generally die-back within 1-2 weeks of exposure. Contact-acting herbicides will usually provide summer long control of target species. Since the root structures are not controlled, regrowth usually occurs the following year.

Reward is the most commonly used contact herbicide for milfoil control in Massachusetts. Regrowth of Eurasian watermilfoil in the year following treatment with Reward can range from no regrowth up to 100 percent regrowth with no discernible pattern among the treated lakes. On average, ACT estimates invasive milfoil regrowth at approximately 50 percent in the lakes we've treated with Reward. Contact-acting herbicides can be either broad spectrum or somewhat species selective depending upon dose, timing of the application and the relative susceptibility of the different plants in the lake. The rapid mode of action with contact herbicides also allows for area-selective control to be achieved through spot or partial lake treatments. Temporary water use restrictions that must be imposed following treatment vary with each contact product. There are no EPA or MA restrictions for swimming for any of the contact herbicides. Prudent pesticide application practice, however, often calls for restricting swimming on the day of treatment. Restrictions on using treated lake water directly to irrigate lawns and gardens will vary from no restriction to a maximum of generally 2-3 weeks. Several of the products carry a temporary restriction for consumption by livestock (i.e. horses, cattle, etc). Only endothall carries a restriction for fish consumption, which extends for a period of three days post-treatment.

Reward is translocated to some extent within the plant. Its rapid action tends to disrupt the leaf cuticle of plants and acts by interfering with photosynthesis. Upon contact with the sediment, diquat is adsorbed immediately and therefore comes biologically inactivated, which means the active ingredient cannot interact with animals or humans. The concentration of Reward in treated water after application at the maximum allowable 2 gallon/surface acre use rate is approximately 0.37 ppm ion immediately after application. Residual levels of Reward in water decline very rapidly, and their reduction is due to the uptake by the weeds and adsorption to suspended soil particles in the water or to the bottom sediment. Reward is practically immobile in sediment and does not pose a significant risk for contamination of well water, which is why it is approved for use in Zone II areas (zones of contribution of water to water supply wells) and in surface water supplies. Photochemical degradation accounts for some loss under conditions of high sunlight and clear water. Usually residues decline to 0.01 ppm or below with 3-14 days after treatment.

Reward was initially proposed for treatment at Lake Cochituate in 2003 and is still an appropriate herbicide for use there, especially so at Middle Pond and possibly some areas of North Pond. Reward is a widely used herbicide, annually applied to greater than 500 lakes and ponds throughout the northeast and probably greater than 75-100 in Massachusetts alone, to control nuisance submersed aquatic plants. Reward would be applied at the application rate of 1.0-1.5 gal/acre. Temporary restrictions on using lake water following treatment with Reward are (1) No direct use of lake water for drinking or cooking for three days, (2) No direct use of lake water for irrigation of turf/food crops for five days, and (3) No direct use of lake water for livestock watering for one day. The are no restrictions on swimming, boating or fishing, but again prudent herbicide/algaecide treatment practices suggest that treated portions of the lake are closed to swimming at least on the day of treatment.

Endothall (Aquathol-K)

Aquathol-K is especially effective on broad-leaved pondweeds and continues to be recommended along with Reward for treatment at the state beach on Middle Pond. The typical application rate for "spot or lake margin" treatment is 2-3 ppm. This low application rate provides a wide margin of safety for birds, fish and other aquatic wildlife found in the lake. Temporary water use restrictions for Aquathol-K are (1) do not use fish from treated areas for food or feed within 3 days of treatment (2) no direct use of treated lake water for irrigation or domestic purposes within 14 days of treatment at the dose that would be applied to just this small portion of Cochituate.

Aquathol-K is a “contact” type of herbicide. It reacts with the cell structure to inhibit protein synthesis. The chemical is taken-up into the plant within 12-24 hours after application. Chemical that is not taken-up by the plants is either broken down very quickly or chemically bound up in the sediment where it undergoes further degradation. Endothall is biodegradable, and It normally disappears from water in 1-10 days after application and from the soil in one to three weeks. Microorganisms are responsible for endothall degradation through Kreb Cycle acid metabolism and use the breakdown fraction of the herbicide as nutrients. No endothall or toxic metabolite is accumulated in water or hydrosoils. When shorelines, moving water, or small portions of a water body are treated, disappearance of endothall is much more rapid. In unenclosed areas, the half-life of endothall in water is typically 48-72 hours or less. Residues in the sediment are similarly transient.

Copper-Based Herbicides (Komeen/Nautique)

Several copper complexes (various forms of copper-carbonate and copper-ethylenediamine) are marketed as contact herbicides. Used alone, these compounds provide typically seasonal control of vascular plants at best. When used in combination with other herbicides like Fluridone (Sonar) or Reward, they can sometimes enhance their effectiveness. In the case of Sonar, these copper compounds help to provide a faster “knockdown” of the target weeds. Copper compounds tank-mixed with Reward will often improve treatment efficacy where the target plants to be treated are heavily coated with filamentous algae. We don’t foresee the applicability of these copper formulations for the current aquatic vegetation problem at Lake Cochituate, unless other recommended herbicides are not desired or approved for use by the regulatory agencies. These copper compounds typically have no temporary water use restrictions post-treatment when applied to ponds, lakes and even drinking water reservoirs.

2,4-D Granular (Navigate/Aqua-Kleen)

Having been used for well over four decades 2,4-D is the oldest and most extensively researched systemic herbicide in the aquatics industry. Granular formulations of 2,4-D ester (Aqua-Kleen & Navigate) are used almost exclusively in the northeast. The granules sink to the bottom where the active ingredient is released over a period of hours to a few days. Plant uptake occurs at the leaves, shoots and root structures. It mimics plant auxins, promoting cell elongation without new cell production. Essentially plants grow themselves to death. Epinasty or the bending and twisting of leaves and stems are the visible signs associated with 2,4-D exposure. 2,4-D is highly selective since it is most effective on dicot, or broad-leafed, species. Commonly managed aquatic dicots include watermilfoils, water chestnut and occasionally water lilies. Most monocot or narrow-leafed species, are only marginally impacted or tolerant of 2,4-D applications. This allows for larger-scale applications to be performed that are fairly species selective. Selective control of non-native and invasive variable watermilfoil (*M. heterophyllum*) and Eurasian watermilfoil (*M. spicatum*) can be achieved with application rates between 75-100 pounds per

surface acre, which is less than half the maximum permissible label rate of 200 pounds per acre. The granular formulation also facilitates fairly successful partial lake or shoreline applications.
In MA, currently 2,4-D cannot be applied in Zone II areas, which precludes its use at Lake Cochituate.

<u>Fluridone (Sonar/Avast)</u>
Sonar (active ingredient fluridone) has often become the herbicide of first choice for managing Eurasian watermilfoil. The maximum application rate in ponds/lakes larger than 10 acres in area is 150 ppb. EPA has also established a tolerance for fluridone in drinking water of 150 ppb. According to the EPA label, drinking water reservoirs can be treated with Sonar at a dose of 20 ppb or less, with no treatment setback requirements or temporary use restrictions. Where the application rate exceeds 20 ppb, there is a 0.25-mile setback (no treat) requirement from the surface water intake structure. There are no EPA or MA restrictions regarding the application of fluridone to water bodies in proximity of groundwater wells. Like Reward, Sonar (fluridone) has been reviewed by MA Office of Research & Standards and can be used in Zone II areas.

Fluridone controls plants by blocking carotenoid (yellow pigments) synthesis, which allows for the chlorophyll to be degraded by sunlight. Effective use of Sonar for control of Eurasian watermilfoil typically requires that the target concentration be maintained in the lake for 45-60 days. Plants, in effect, starve to death. This happens very slowly often requiring 45-90 days for plants to completely die-off. One advantage of this slow die-off is that there is not a large release of nutrients into the water that might be available for algae growth, and there are no significant changes in the dissolved oxygen concentrations. Plant uptake and photo-degradation are the prime modes of fluridone degradation. The half-life of fluridone in water averages roughly 20 days but will vary. Symptomatic chlorosis, the whitening or bleaching of plants, is highly visible in some species. There are no restrictions post-treatment with Sonar for swimming, fishing or consumption by livestock. Treated waters should not be directly used for irrigation until the concentration drops below 10 ppb for most plants and less than 5 ppb for sensitive species that are identified on the product label.

Sonar was not initially proposed for use in 2003 at Lake Cochituate, primarily since the chemical cost alone to treat South Pond with Sonar would approach the maximum budget that DEM had available for the entire project at that time. Sonar is highly soluble in water and therefore, shoreline or partial lake treatments are generally ineffective due to dilution of the product away from the targeted treatment area. Use of the liquid Sonar AS formulation at the South Pond of Lake Cochituate would require treating the entire approximate 246-acre pond when there are only about 64 acres of actual milfoil cover at the present time.

The manufacturer of Sonar (SePro Corp) has developed several pellet formulations of Sonar (Sonar SRP, PR & Q formulations) to assist efficacy when performing partial lake applications. These different pellet formulations provide varying release rates over time in either static or flowing water situations. While some good success has been achieved with the different pellet formulations at some sites, the rate at which the chemical is released from the pellet will vary considerably depending upon the sediment type and other factors. Therefore, it's difficult to accurately predict the concentration of fluridone that will be found in the water post-treatment, despite knowing the actual dose that was applied. Proper dosing is very important with Sonar applications, especially where selective plant control is desired. At higher doses above 20 ppb, Sonar is more of a broad spectrum herbicide, controlling many species of submersed and floating-leaved species. At lower doses, Sonar can be quite selective for control of Eurasian watermilfoil although variable watermilfoil often requires a somewhat higher (more than 20 ppb) dose. Extensive Eurasian watermilfoil treatment experience throughout the northeast and across the northern US has demonstrated good control of milfoil at a low dose of just 6 ppb with generally limited impacts to non-target plants. The duration of milfoil control can be extended from generally 1-2 years when treating at a dose of approximately 6 ppb to generally 2-3 years or longer when treating at a dose in the range of approximately 8-10 ppb. Impacts to non-target plants may be slightly greater during the year of treatment at this somewhat higher dose, however, experience and the literature shows that the non-target plants generally recover well within 1-2 growing seasons and the post-treatment plant diversity may often increase from pre-treatment conditions as the undesirable species are eliminated. This technology of lower dose Sonar applications was further advanced by the development of an immunoassay test (FasTEST) procedure, developed by SePro Corp. to accurately and rapidly measure in-lake fluridone concentrations and guide the timing and concentration of "booster" applications.

Triclopyr (Renovate 3)

EPA granted full aquatic registration for Triclopyr (trade name Renovate) in the fall of 2002. MA registration is still pending; however, SePRO (the manufacturer of Renovate) is optimistic it will receive MA registration in 2004 or 2005. Whether Renovate could be used in Zone II areas in MA remains to be seen. Reportedly it has a low mobility in sediment, and under the federal label there are no treatment restrictions for nearby wells. Specific no treat set-back distances from direct, potable water intakes are provided on the EPA label. It has been used in the turf, forestry and right-of-way industries to control terrestrial plants for many years under the trade name Garlon 3A. Triclopyr is an auxin mimic systemic herbicide that targets dicot or broad-leafed plants, with a mode of action similar to that of phenoxy herbicides like 2,4-D. It is translocated throughout the entire plant killing the stem, foliage and roots. It only requires a short contact time with targeted plants, so it can be used for partial lake treatments. Presently, it is formulated as a concentrated liquid. Dosing is based on the volume of water being treated. Demonstration treatments performed under an Experimental Use Permit (EUP) issued by the EPA showed that species-selective control of submersed Eurasian watermilfoil and emergent purple loosestrife could be achieved. While Renovate cannot be currently used at Lake Cochituate, it could prove to be an important management tool for follow-up, spot or shoreline treatments of milfoil in future years.

NO ACTION ALTERNATIVE

Taking no action to control and prevent further infestation of Lake Cochituate with milfoil or other non-native species would be inconsistent with the current and future management objectives of DCR and the uses of the lake by abutters and visitors. No action to control the invasive aquatic plants would significantly alter the recreational and ecological values of the lake, and therefore, is not an acceptable alternative. Some "natural" milfoil crashes have been documented, but they are relatively infrequent and the causes are uncertain. Increases in milfoil cover within a lake are usually the norm. Many states (i.e. MN, WI, WA, VT) including Massachusetts have also documented increased numbers of lakes with milfoil infestations in recent years.

Milfoil cover in Lake Cochituate was not well documented prior to the 2003 surveys; however, there did appear to be expanded cover in South Pond within the past year, and the spread into Middle and North Ponds is unquestioned. Allowing milfoil to grow unabated will enable it to out-compete more desirable native plants. This would likely result in large, dense stands of milfoil growth. Resulting monocultures decrease fish and wildlife habitat, can greatly impair recreation and reduce property values. Lakes with dense milfoil beds throughout the littoral zones often develop filamentous algal growth on top of the milfoil, which further restricts access and degrades water quality. Dense floating mats of milfoil fragments often develop in lakes where recreational boating pressure is significant. Ultimately, increased milfoil cover would cause more biomass deposition each year and accelerate the eutrophication of the entire lake.

RECOMMENDED MANAGEMENT PROGRAM

Developing a Long Range Vegetation Management Plan for Lake Cochituate requires the integration of several different management strategies. Based on the findings in the preceding sections, the four applicable weed control strategies for Lake Cochituate are hand-pulling, benthic barrier installations, suction harvesting and herbicide treatments. The principal management objective is to selectively control milfoil and other non-native vegetation in order to preserve and in some cases restore habitat diversity for aquatic fauna, while maintaining and/or improving recreational access. All four techniques should be used where appropriate and practical to achieve these goals. One premise of the management program will be reducing the frequency and scope of herbicide applications to the lake over time. Most lake management researchers and industry professionals agree that herbicides play an important role in the management of non-native and invasive aquatic plant growth, often with fewer environmental impacts than other approaches and negligible risk to humans and non-target species when applied in accordance with label directions. Of the four techniques discussed for Lake Cochituate, herbicides provide the only technique applicable to large areas of infestation, and will be a critical part of the overall vegetation management plan. However, other techniques are recommended, and the plan provides for an integrated management approach.

The first and most important step in developing a vegetation management plan for a large lake like Lake Cochituate is to establish a set of criteria to help determine which management technique is best suited for a particular section of the lake. The criteria that were developed by Dr. Kenneth Wagner and Gerald Smith (Fugro/ACT, respectively, 1995) for the Eurasian watermilfoil control project at Lake George in New York can be similarly applied to Lake Cochituate. However, it is important to note that Lake George is under jurisdiction of the Adirondack Park Agency, which has a restrictive view towards in-lake management and aquatic herbicides in particular. Determining where each technique should be used was based on several factors, including percent milfoil cover, area impacted, milfoil biomass, milfoil dominance and other environmental constraints. This is depicted in the Flow Chart shown on the following page. Several different factors may need to be considered to determine which technique is most appropriate for a given area. In many cases, more than one approach may be used. Cost of the various approaches is not listed in the flow chart as a determining factor, but in reality, cost will enter into the decision making process. Using this set of criteria is intended to be a guide, but it is not a substitute for site-specific inspections of the areas requiring management and recommendations of lake management professionals that take into account other considerations. It must also be stressed that the milfoil infestation at Cochituate will be a “moving target” and assessments will need to be constantly performed and management strategies adjusted. Areas where hand-pulling appears to be appropriate in the late spring, may require suction harvesting or herbicide treatment by mid-summer. This was clearly the case on Middle Pond in 2003. The area between the boat ramp and the connection to North Pond appeared to have sparse milfoil cover in June, but coverage had increased considerably by August.

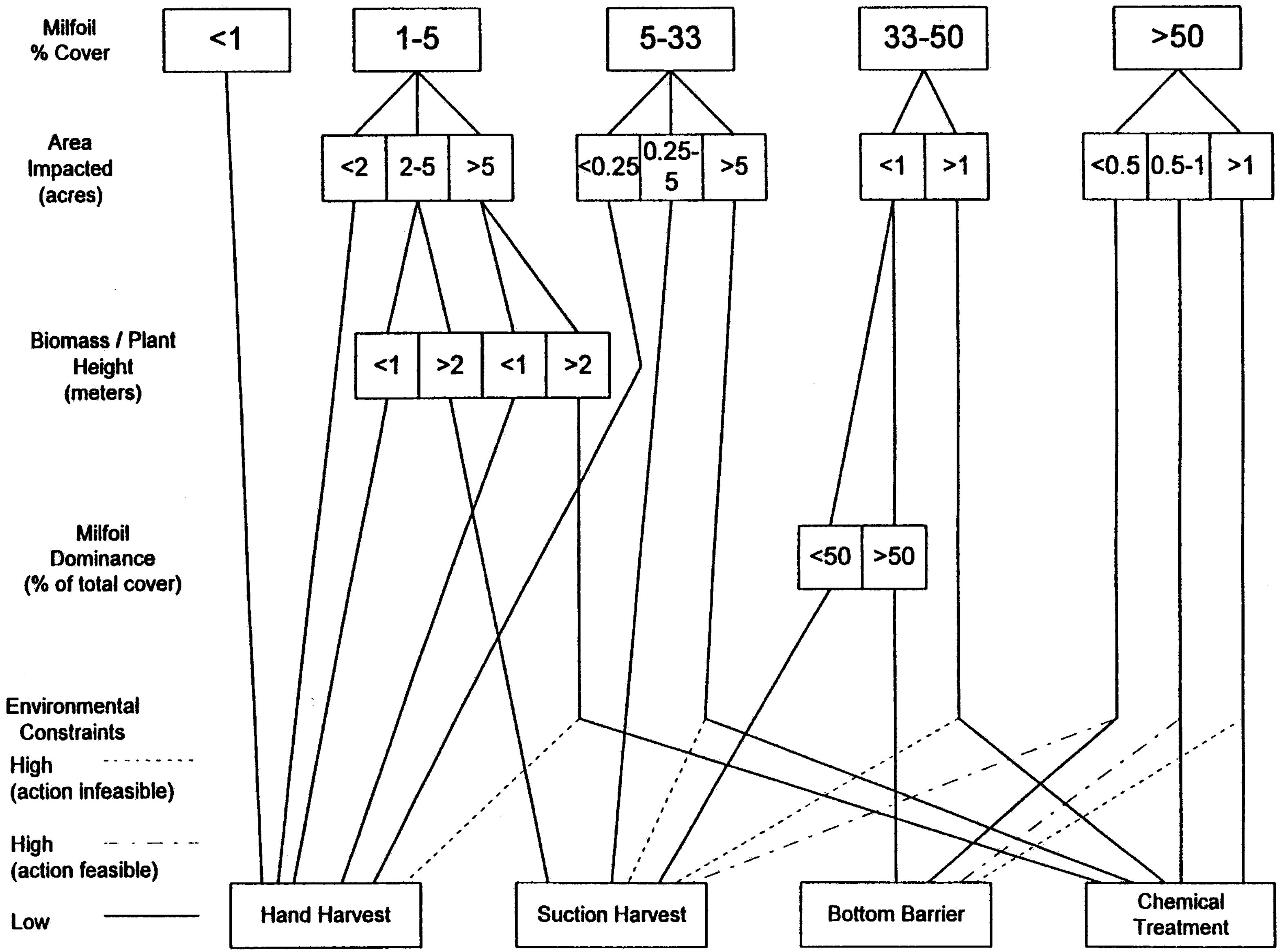
For the most part, hand-pulling will be limited to areas with very sparse milfoil growth (generally less than 500 stems per acre or less than 1 percent cover). Occasionally, it will be appropriate for areas with slightly higher milfoil densities (up to 10 percent cover) when confined to relatively small areas (less than 1-2 acres). Attempting to hand-pull higher density milfoil cover will be inefficient and do more harm than good through excessive fragmentation and diver disturbance to the bottom. Costs to contract for hand-pulling services will vary depending on personnel. Assume $140 per hour for a hand-pulling crew consisting of one SCUBA diver, one person with snorkeling gear, one boat tender and equipment. Unit costs for hand-pulling have been estimated at less than $500 per acre to remove sparse milfoil growth or areas with less than 500 stems per acre (Wagner 2003). The mapping performed during the 2003 surveys did not include milfoil stem counts per acre, but considerably higher milfoil densities were noted in several areas listed as having less than 5-10 percent cover. A 10 percent increase in milfoil cover could easily translate into a 10-fold increase in unit costs. For that reason we have assumed a mixed density of sparse milfoil cover and an average hand-pulling unit cost of $2500 per acre.

Very small patches (less than 0.25 acres) with high milfoil cover (greater than 50 percent) and dominance may be suitable for bottom barrier installations. Installing barriers to areas larger than 0.25 acres will be too costly and labor intensive, and will likely carry unacceptable non-target impacts. The 7,000 square feet of Aquascreen purchased by DCR and installed around the State Park beach and swim area in 2003 may be reused at other locations in the future. Material purchase and installation costs were $1.65 per square foot or roughly $72,000 per acre in 2003. Follow-up retrieval and redeployment costs will probably run half to two-thirds of the initial cost.

It should be noted that suction harvesting is a relatively new technique in Massachusetts and has not yet been permitted in the state. The Department proposes to carry out a demonstration project of suction harvesting (or hand pulling with suction removal) in one or two locations in Middle or South Pond to provide an evaluation of the technique for potential future use. The project site(s) would be selected based on bottom sediment types, vegetation densities and other factors. Monitoring of pre- and post-harvesting conditions will be documented and included in a follow-up letter report. Similar to hand-pulling, there is considerable variability in cost depending on milfoil density and a host of other factors. The high end of the cost range or $14,500 per acre was used for budgeting purposes to factor in equipment rental or a depreciated equipment purchase price over a several year period. As noted, actual costs will vary.

Herbicide treatment costs vary depending on the herbicide being applied. The two contact herbicides proposed for Middle Pond Reward (diquat) and Aquathol K (endothall) have fairly fixed unit costs. For smaller areas (less than 5-10 acres) Reward treatments will typically cost $400-$500 per acre, while Aquathol K treatments are probably $600-$700 per acre. When treating more than 10-20 acres with Reward and Aquathol K, unit treatment costs may be somewhat lower. Costs for whole-lake treatments with liquid fluridone (Sonar AS) often break down to less than $300 per acre, but that includes non-vegetated areas. In deeper lakes with littoral zone milfoil growth like that found at Lake Cochituate, the treatment cost is probably closer to $1000 per acre of milfoil growth. Shoreline or spot-treatments that might be performed with fluridone pellets (Sonar PR & Q) will likely be in the $1000-$2000 per acre range.

Figure 5. Flow Chart for Determining Site-Specific Control Techniques.



Note: This flow chart constitutes a guideline, not a set of absolute choices. Please refer to the discussion in the text of the report for further considerations.

SOURCE: *Lake George Milfoil Control Evaluation* *Fugro/ACT*

YEAR 1 – RECOMMENDED VEGETATION MANAGEMENT PROGRAM

A basin by basin breakdown of the recommended program components for Year 1 of a vegetation management program at Lake Cochituate is shown below. The selection of techniques was made using the criteria discussed above and is initially based on the relative abundance of milfoil that was found in each basin in 2003 (see Table 5). **However, it must be reiterated that these recommendations are best estimates based on conditions observed in 2003 and providing for some expansion of milfoil cover and density by spring 2004. Adjustments to the program will almost certainly be necessary following inspections performed immediately prior to the implementation of recommended strategies**. Recommended locations where the various management strategies should be implemented are depicted in Figure 11.

Table 5 – Summary of 2003 Milfoil Cover in Lake Cochituate by Basin

% Milfoil Cover	***North Pond (acres)***	***Middle Pond (acres)***	***South Pond (acres)***	**TOTAL (by % cover)**
<10%	1.4	10.4	7.6	*19.3*
10-25%	0.4	9.9	6.6	*16.8*
25-50%			16.1	*16.1*
50-75%		0.4	30.7	*31.1*
>75%			3.1	*3.1*
TOTAL (by basin)	*1.7*	*20.7*	*63.9*	

<u>South Pond</u>

Herbicide treatment with Fluridone (Sonar) is recommended in the first year of the program to manage the widespread infestation of Eurasian watermilfoil. The approximate cost for treating all of South Pond with Sonar is $65,000, inclusive of chemical, application services, and limited herbicide residue testing. Control of the milfoil is anticipated for 2-3 years. In comparison, treatment of all milfoil in the South Pond (except within approximately 1,000 ft. of the Town Well Field) with Reward would cost approximately $20,000 with good control anticipated during the year of treatment. Milfoil regrowth is projected at 50 percent in the year following treatment and beyond. When considered over a three-year period, the costs for treating with either Sonar or Reward are fairly comparable although Reward might run approximately 25 percent less. There is less disturbance to the lake's ecosystem when larger scale treatments are not being repeated each year.

Cost is just one consideration of selecting the primary herbicide to use in South Pond. Other factors include selectivity and effects on non-target plants, temporary water use restrictions post-treatment and other concerns (see Table 6).

Table 6 – Advantages and Limitations of Sonar versus Reward for South Pond

Criteria	Sonar (fluridone)	Reward (diquat)
Efficacy on invasive milfoil	▪ Effective on M. spicatum at low dose ▪ Higher dose required or may not be effective on M. heterophyllum	▪ Effective on both species
Time required to achieve milfoil control	▪ Typically 45-60 days	▪ Typically 7-14 days
Timing of herbicide application	▪ Typically mid May – late June	▪ Mid May – late July
Use in Zone II areas	▪ approved	▪ approved
Water use restrictions	▪ None for swimming & fishing ▪ Direct irrigation restriction typically for 30-60 days	▪ None for swimming & fishing ▪ Direct irrigation & drinking 3-5 days ▪ Direct livestock watering 1 day

Relative susceptibility and probable effects of a low dose (8-10 ppm) fluridone treatment on non-target plants found at South Pond follows.

Table 7 – Comparative Susceptibility of Sonar versus Reward to Aquatic Vegetation in Lake Cochituate

Macrophyte Species	Common Name	Susceptibility to Sonar (fluridone)	Susceptibility to Reward (diquat)
Ceratophyllum demersum	Coontail	S	S
Elodea canadensis	Elodea	S	S
Filamentous algae		T	S – I
Myriophyllum heterophyllum	Variable watermilfoil	I – T	S
Myriophyllum spicatum	Eurasian watermilfoil	S	S
Najas flexilis	Naiad	S	S
Nitella sp.	Stonewort	T	I – T
Nuphar variegatum	Yellow Waterlily	S – I	T
Nymphaea odorata	White Waterlily	S – I	T
Pontederia cordata	Pickerelweed	T	T
Potamogeton crispus	Curlyleaf pondweed	S	S
Potamogeton gramineus	Variable-leaf pondweed	I – T	S – I
Potamogeton perfoliatus	Clasping-leaf pondweed	I	I
Potamogeton pusillus	Thin-leaf pondweed	S – I	S
Potamogeton richardsoni	Richarsons pondweed	I	I
Potamogeton robbinsii	Robbins Pondweed	T	I – T
Sagittaria teres	Arrowhead	T	I – T
Utricularia sp.	Bladderwort	I – T	S – U
Valisneria americana	Wild Celery	I – T	T
Wolffia sp.	Watermeal	T	I – T

[S – sensitive; I – intermediate; T – tolerant; U – unknown]

[1] Plant susceptibility to Sonar adapted from information published by SePRO, prior low dose (≤ 10 ppb) milfoil treatment experience of Aquatic Control Technology, Inc. and reports from other professional applicators. Plant susceptibility, however, will vary from lake to lake.

There is not a lot of difference in the susceptibility of non-target plants in Lake Cochituate between the two herbicides. Fluridone or diquat will rarely kill emergent and shoreline plants unless the herbicide is inadvertently applied directly to their foliage. Fluridone will likely have less impact overall on the pond's predominant floating-leaved and submerged plant community over time, since species that reproduce by seed and other reproductive structures will rebound in the years following the initial treatment. Where diquat may require treating a substantial portion of the pond each year, the impact on non-target plants is repetitive but with diquat not all of the South Pond shoreline and littoral area need to be treated. With either herbicide, impacts on non-target plants are not likely to be excessive and native plants will adapt to the changing environment.

Sonar is not likely to control the variable watermilfoil in South Pond at a dose of 8-10 ppb. We recommend that the dose of Sonar in those areas of variable watermilfoil growth, either be increased by also applying Sonar pellets over the infested area or else treat those areas of variable watermilfoil that do not respond to Sonar with Diquat. It should be noted that the recommendation for Sonar in South Pond is based on the increased density and areal cover of milfoil since the original Notice of Intent was filed with the Natick Conservation Commission. While Reward still could be used, Sonar will likely provide greater benefits over time, as discussed.

Middle Pond

At least three and possibly all four of the recommended management strategies should be utilized on Middle Pond in Year 1 of the program. Herbicide treatment is recommended for three locations; Area (1) the cove areas located between the boat ramp and the connection to North Pond at the Route 30 overpass; Area (2) around the State Park beach and swim area; and Area (3) the southern shoreline and the small cove leading to Carling Basin.

Area 1 encompasses approximately 15 acres of mixed milfoil cover. Treatment with Reward (diquat) herbicide is recommended at an estimated treatment cost of $6000-$7500. Roughly one-third of the area supports less than 10 percent cover, while the remaining two-thirds have 10-25 percent cover. There is also one small, dense patch (50-75 percent cover) near the boat ramp. Much of this area is shallow and has mucky bottom sediments. The cove located between the Mass Pike and Route 30 overpasses (confluence of Snake Brook) also supports moderate to abundant densities of native plants. Relying on hand-pulling and suction harvesting to clear this area would be inefficient due to reduced visibility and excessive fragment creation. Assuming a suction harvester can clear 500 ft^2/hour (GEIR 2004), more than 80 operating days would be needed to clear the moderate milfoil growth from this area, with an estimated cost of more than $116,000. Another $20,000 worth of hand-pulling may also be needed in the same area.

Treatment of approximately 2.5 acres with Aquathol K (endothall) and Reward (diquat) is recommended for Area 2 at an estimated treatment cost of $1,750. This location has a mix of milfoil and native pondweeds that are growing at nuisance densities, requiring both herbicides for effective control. Managing weed growth at this location is necessary for swimmer safety. It is also an area subject to considerable fragmentation due to the amount of swimmer activity. Hand-pulling and suction harvesting are not appropriate in this location because there is too much plant biomass to be removed. Furthermore, portions of the swim area would need to be temporarily cordoned off during hand-pulling or suction harvesting operations. More than 7000 square feet of benthic weed barriers were installed around the outer edge of the swim area in 2003. There is still nuisance weed growth beyond these barriers. Installing more barriers would be inefficient.

Treatment with Reward (diquat) herbicide is recommended for Area 3 along the southern shoreline and in the small cove that leads to Carling Basin. This totals approximately 2.5 acres and will likely carry a treatment cost in the range of $1250.

Hand pulling is recommended for the remaining milfoil growth, mostly found in sparse patches along the eastern shoreline. This totals approximately 1.7 acres and carries an estimated removal cost of $4250.

North Pond

Based on observations made in 2003, the milfoil growth in North Pond should be able to be effectively controlled with hand-pulling. Benthic barriers may be considered if small dense patches are encountered. Use of barriers purchased by DCR in 2003 is anticipated for budgeting purposes. Repositioning charges would be similar to the hourly diver charge rates for hand-pulling. Purchasing and installing new barrier would cost in the range of $1.65 per square foot or in excess of $70,000 per acre.

North Pond presently benefits from having the least milfoil cover of the three major basins, and the milfoil that was found was present in very low densities and probably represents new growth from the 2003 season. Every effort should be made to control and prevent any further expansion of milfoil in North Pond. If milfoil cover expands beyond what can be efficiently hand-pulled over covered with benthic barriers, then herbicide treatments should be utilized immediately. Controlling the plants early before they develop large root crowns is important.

Hand-pulling is recommended for the majority of the basin, since when milfoil was encountered in 2003 it was generally found in very sparse densities. A total of 1.8 acres may require hand-pulling at an estimated cost of $4500.

Other Program Costs

A significant consulting effort will be needed for monitoring and permit compliance. Consulting charges will be higher if an integrated management program is pursued. Early season survey work will be needed in milfoil infested areas to identify water depth, bottom type, plant density, presence of non-targets and other operational considerations needed to determine the which management strategy will be employed. Sizeable hand-pulling and suction-harvesting efforts will necessitate direct oversight and project coordination at least twice per week, if not more frequently. Comprehensive plant mapping will need to be performed before and after management strategies are employed to evaluate efficacy of each approach and impact to non-targets. Lake-wide water quality monitoring will likely be required on a routine basis, especially if suction-harvesting or herbicide treatments are performed. Additional permitting and permit compliance tasks should also be anticipated. The annual consulting effort needed to support an integrated vegetation management plan at Lake Cochituate may approach $30,000. Some of the costs of monitoring can be offset by DCR staff setting up a Weed Watcher group at Lake Cochituate, and some of the oversight also might be assumed by DCR staff, thus reducing the budget for this item.

Table 8 - Year 1 Budget Estimates for Integrated Vegetation Management Plan at Lake Cochituate

(Note: The management techniques shown below are recommended, but may be modified depending on current conditions)

Lake Basin	**Vegetation Management Strategies & Associated Tasks**	**Recommended Budget**
South Pond	Sonar (fluridone) herbicide treatment of entire pond	$65,000[1]
	Additional management of *M. heterophyllum* – follow-up treatment with Reward (diquat) herbicide or hand-pulling if plants are not completely controlled by Sonar	$5000
Middle Pond	Reward (diquat) herbicide treatment of 15 acres between the boat ramp and connection to North Pond ($400-$500/acre)	$7500[1]
	Aquathol K (endothall) and Reward (diquat) treatment of 2.5 acres around the State Park beach and swim area ($600-$700/acre)	$1750[1]
	Treatment with Reward of the milfoil cover along the southern shoreline and in the small cove leading to Carling Basin (2.5 acres @ 400-500/acre)	$1250
	Hand-pulling of sparse milfoil cover primarily found along the eastern shoreline (1.7 acres @ $2500/acre)	$4250
North Pond	Hand-pulling and/or benthic matting placement to control moderate milfoil cover in the small cove on the eastern shoreline adjacent to Wayland Town Beach (0.4 acres @ $2,500/acre)	$1000
	Hand-pulling of sparse milfoil cover primarily found near shore in the southern half of the basin (1.4 acres @ $2500/acre)	$3500
Other Program Costs	Permitting – prepare and file NOI applications in 3 communities, prepare and file DEP License to Apply Chemicals	$10,000
	Fragment barrier deployment and maintenance to contain milfoil fragments during suction harvesting and hand pulling operations	$7500
	Project oversight, inspections and reporting	$30,000
	Contingency budget – 10% of total project cost	$14,000
	ESTIMATED TOTAL COST OF YEAR 1 PROGRAM	**$150,750**

[1] Treatment costs assume the cost of all chemicals, labor and equipment for the application. They also include limited post-treatment monitoring of herbicide residues. More extensive monitoring/testing requirements or compliance with additional permit conditions are additional.

PROGRAM CONTINUATION – YEARS 2 & 3

To effectively control milfoil and other aquatic invasive species in Lake Cochituate, DCR and the communities around the lake need to commit to an ongoing comprehensive vegetation management program for the foreseeable future. Monitoring and assessment will play a critical role in determining where and what management strategy should be used, and an educated and involved citizenry can play a key role in various aspects of the effort.

Annual consulting services of $30,000 as previously described should be allocated for project oversight, monitoring and permit compliance. Survey methods will need to be repeatable and provide some quantitative measures of milfoil cover and native plant cover so that the effectiveness of the various management strategies can be properly assessed. The scope of these consulting services will depend on which and how many different management strategies are being utilized. The management strategies used at Lake Cochituate in Years 2 and 3 of the program will remain unchanged, but they will be implemented differently.

South Pond

If South Pond is treated with Sonar (fluridone) herbicide in Year 1, follow-up milfoil control efforts in Years 2 and 3 should be nominal. In most cases, two or three years of nuisance level milfoil control is achieved following a Sonar treatment. The focus of follow-up milfoil efforts on South Pond will likely be control of *M. heterophyllum*, which may not be completely controlled by a low-dose Sonar treatment. Spot treatment with Reward (diquat) herbicide is recommended to control remaining stands greater than 0.5-1 acre of *M. heterophyllum.* In areas located within 1000 feet of the Springvale Well Field, suction harvesting will likely be required. Aggressively controlling milfoil regrowth is preferable to re-treating the entire basin with Sonar every third or fourth year. This approach will result in more drastic habitat changes and may hinder the establishment of native vegetation or have negative impacts on the fishery. Furthermore, allowing milfoil to grow unmanaged in South Pond for one or two years between treatments will provide a constant source of plant fragments to infest Middle and North Ponds.

If herbicide treatment is not carried out in year 1, given the extent of invasive plants in South Pond, there are no feasible alternatives for lake-wide management. The Department will install buoys to warn boaters away from the most heavily infested areas and will maintain netting to control plant fragments from entering Middle Pond. The Dept will continue to monitor the plant growth and periodically inspect and clean the nets.

MIddle and North Ponds

It is more difficult to predict follow-up management requirements at Middle and North Pond, considering the variability of control for the recommended management techniques and the exponential growth potential of milfoil. It is realistic to assume a similar level of milfoil management will be required at Middle and North Ponds in Years 2 and 3, even if the strategies end up being used in different locations. To simplify budget projections, the Year 1 program costs for each basin are assumed for Years 2 and 3 of the program.

If no herbicide treatment is allowed in Middle Pond in Year 1, the Department will carry out hand pulling and/or other methods in selected areas of Middle Pond, depending on the results of the demonstration project. The focus will be on keeping the boat ramp and the swim beach as free of plant growth as possible. In North Pond, the emphasis will be on protection against additional infestation by hand pulling, maintenance of netting, and careful monitoring. Middle Pond has some large areas of infestation not suitable for hand pulling or similar techniques. The Department proposes to buoy off these areas with signs intended to prevent boaters from entering and creating or transporting plant fragments. Nonetheless, these areas will remain sources of future infestation.

In summary, based on available technology there is no feasible way to permanently eradicate milfoil. Milfoil can be effectively managed and the recreational uses and ecology of the lake and its associated resources can be maintained through diligent management efforts. A very diligent management effort may retard and prevent further spread of milfoil. Based on the available alternatives, herbicide use affords the most cost-effective management tool for continued milfoil control. The benefits of herbicide treatment can be augmented and extended by employing non-chemical techniques like hand-pulling where appropriate. When properly used, herbicide treatment over larger areas of milfoil may be less disruptive than other non-chemical techniques that are also recommended at Lake Cochituate.

Table 9 - Follow-Up Budget Estimates for Continuation of Vegetation Management Plan at Lake Cochituate

(Note: These recommendations will vary depending on what techniques are used in Year 1)

Lake Basin	Follow-up Management Strategies	Year 2 Cost Estimates	Year 3 Cost Estimates
South Pond	Reward (diquat) herbicide spot-treatment to control remaining *M. heterophyllum* and dense regrowth of *M. spicatum* ($400-$500/acre)	$5000	$15,000
	Suction harvesting of areas located within 1000 of Town Well Field and other suitable locations ($14,500/acre)	$10,000	$10,000
	Hand-pulling of sparse milfoil cover ($2500/acre)	$5000	$10,000
Middle Pond	Reward (diquat) and Aquathol K (endothall) herbicide treatments ($400-$700/acre)	$10,500	$10,500
	Hand-pulling of sparse milfoil cover primarily found along the eastern shoreline ($2500/acre)	$4250	$4250
North Pond	Hand-pulling of sparse milfoil cover ($2500/acre) and/or benthic matting placement	$2500	$3500
Other Program Costs	Permitting – compliance with Orders of Conditions, prepare and file DEP License to Apply Chemicals	$5000	$5000
	Fragment barrier deployment and maintenance to contain milfoil fragments during suction harvesting and hand pulling operations	$7500	$7500
	Project oversight, inspections and reporting	$30,000	$30,000
	Contingency budget – 10% of total project cost	$8000	$10,000
TOTAL	**ESTIMATED PROGRAM COSTS**	**$87,750 Year 2**	**$105,750 Year 3**

TOTAL PROJECTED 3-YEAR PROGRAM COST $344,250

Note on Program Recommendations:

The program recommendations contained herein were made largely irrespective of cost. The Department will need to identify the preferred management plan based on available funds and environmental and other considerations. Herbicide treatment will almost always be more cost-effective than either suction harvesting or bottom weed barriers. All methods of vegetation management will have some adverse effects on non-target plants and animals. The challenge is in applying these different techniques in such a way so as to mitigate the occurrence of significant or unacceptable adverse effects. Suction harvesting is a technique that has limited experience here in MA. MA DCR supports a holistic approach to lake and aquatic plant management and in that light, DCR is agreeable to support the demonstration of this technique at Lake Cochituate. Data and information gathered from the use of suction harvesting along with hand pulling, bottom barriers and herbicide treatments will have relevancy and benefit state-wide.

The recommendations in this plan are consistent with and include the recommendations and performance standards contained in the Generic Environmental Impact Report, *Eutrophication and Aquatic Plant Management in Massachusetts* and *The Practical Guide to Lake and Pond Management in Massachusetts,* as approved by the Secretary of the Executive Office of Environmental Affairs, March 19, 2004.

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Appendix A

Figures

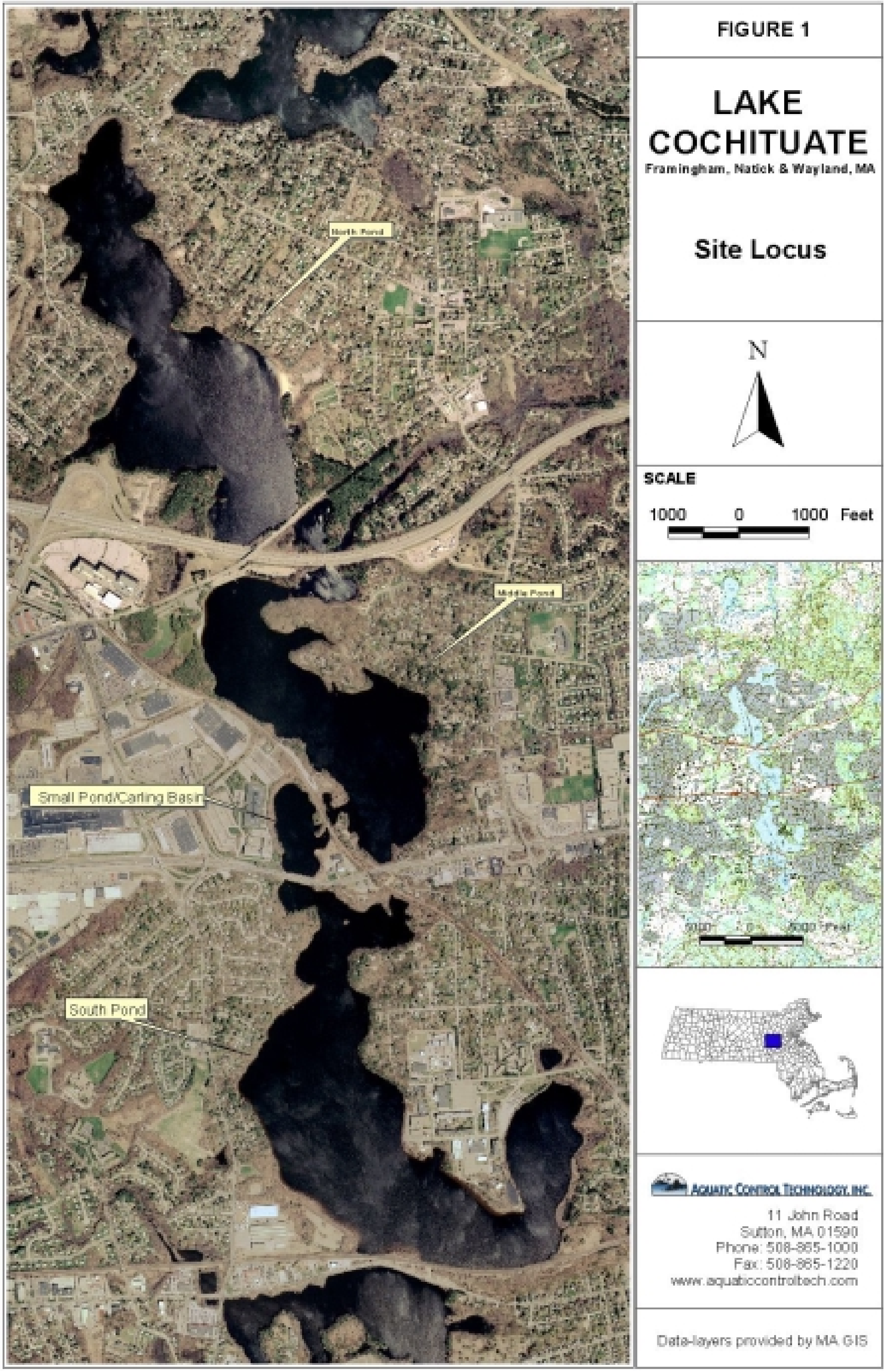

FIGURE 1
LAKE COCHITUATE
Framingham, Natick & Wayland, MA
Site Locus
N
SCALE
1000 0 1000 Feet
North Pond
Middle Pond
Small Pond/Carling Basin
South Pond
AQUATIC CONTROL TECHNOLOGY, INC.
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Sutton, MA 01590
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www.aquaticcontroltech.com
Data-layers provided by MA GIS

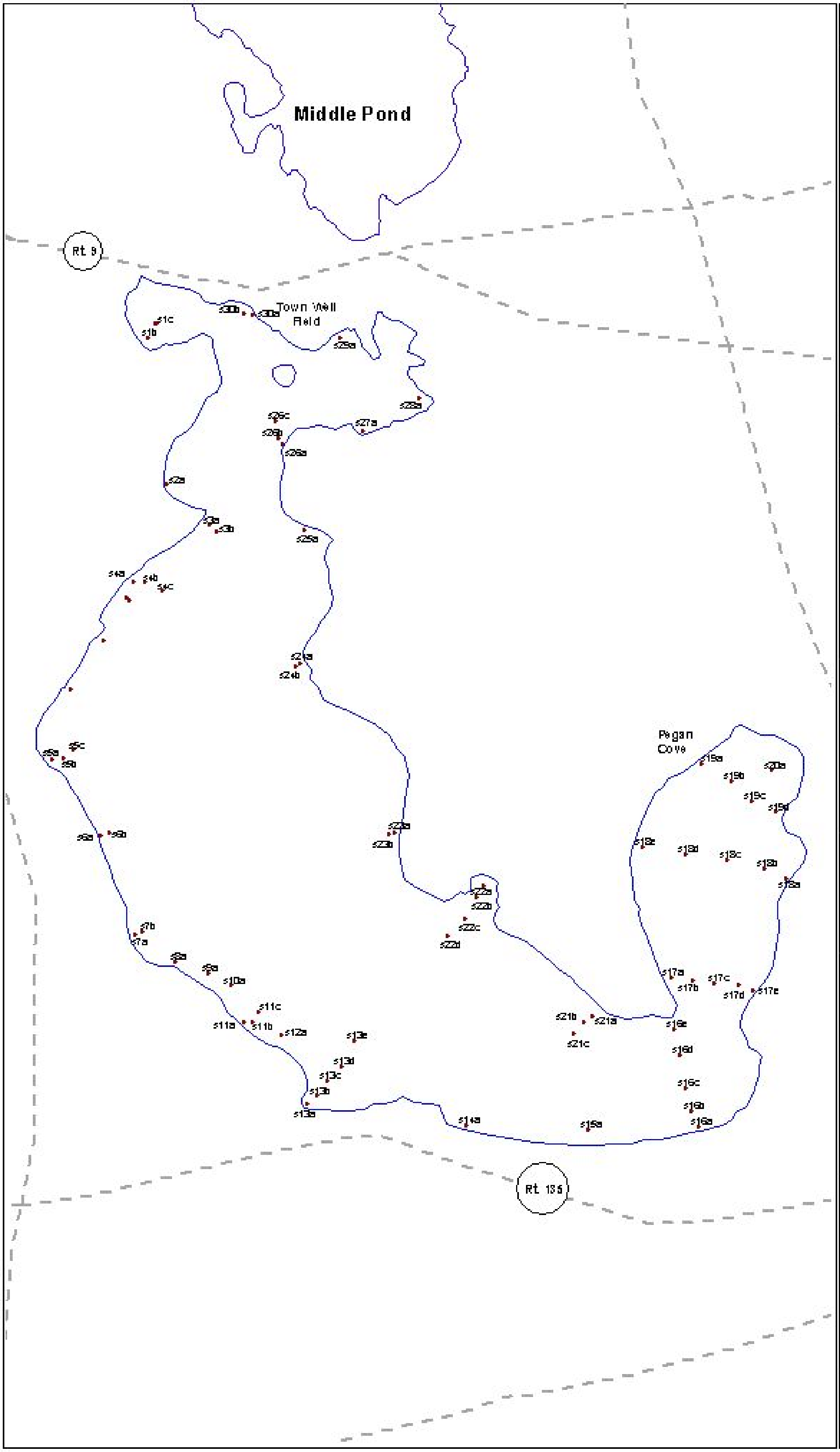


FIGURE 2

LAKE COCHITUATE

Framingham, Natick & Wayland, MA

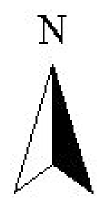
South Pond Survey Data Point Locations

Survey Date	Map Date
6/12/03 & 10/3/03	2/13/04

LEGEND

Data Collection Point

Major Roadways



SCALE

500 0 500 Feet

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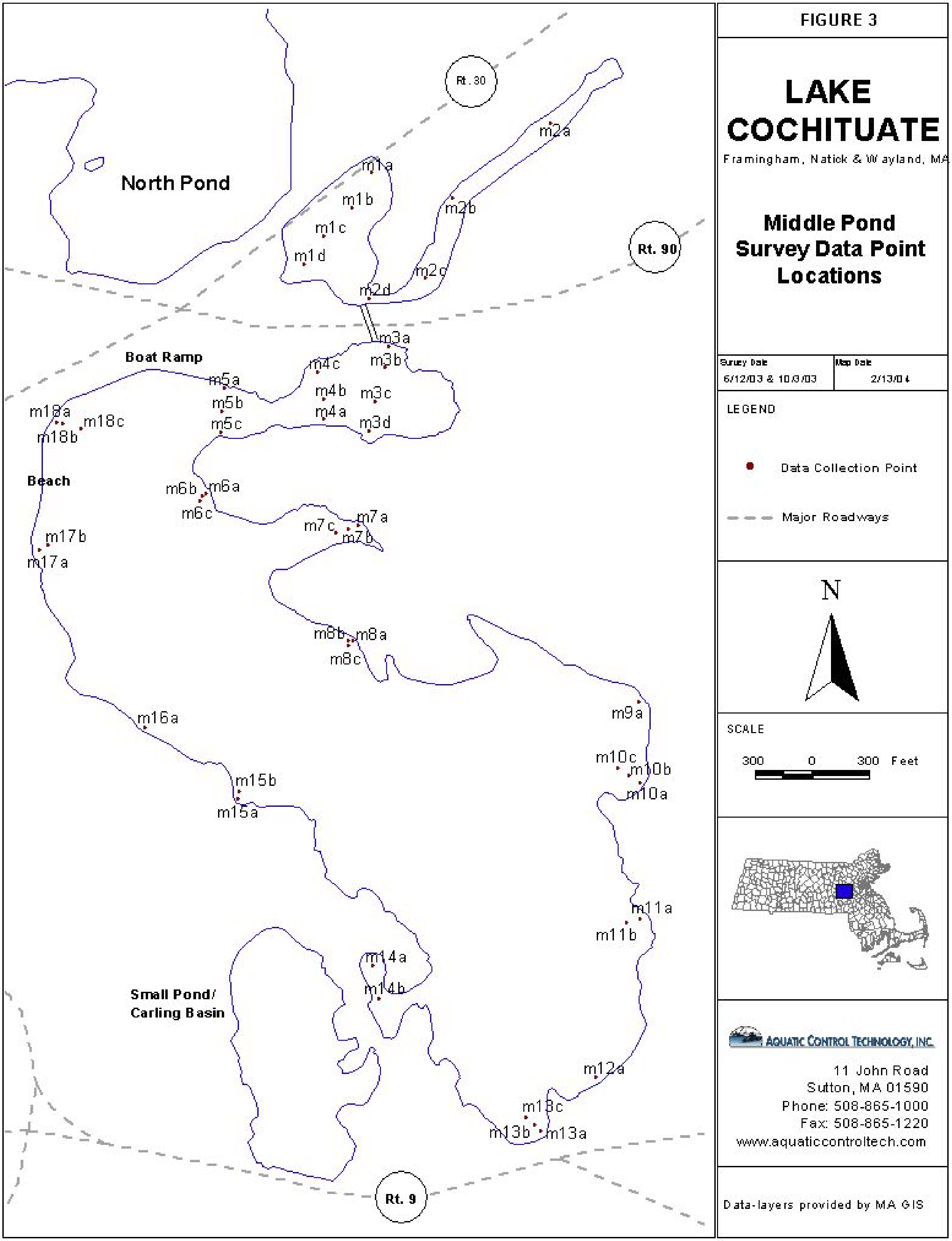
FIGURE 3
LAKE COCHITUATE
Framingham, Natick & Wayland, MA
Middle Pond Survey Data Point Locations
Survey Date
6/12/03 & 10/3/03
Map Date
2/13/04
LEGEND
Data Collection Point
Major Roadways
N
SCALE
300 0 300 Feet
AQUATIC CONTROL TECHNOLOGY, INC.
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Sutton, MA 01590
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Fax: 508-865-1220
www.aquaticcontroltech.com
Data-layers provided by MA GIS
North Pond
Rt. 30
Rt. 90
Rt. 9
Boat Ramp
Beach
Small Pond/
Carling Basin
m1a
m1b
m1c
m1d
m2a
m2b
m2c
m2d
m3a
m3b
m3c
m3d
m4a
m4b
m4c
m5a
m5b
m5c
m6a
m6b
m6c
m7a
m7b
m7c
m8a
m8b
m8c
m9a
m10a
m10b
m10c
m11a
m11b
m12a
m13a
m13b
m13c
m14a
m14b
m15a
m15b
m16a
m17a
m17b
m18a
m18b
m18c

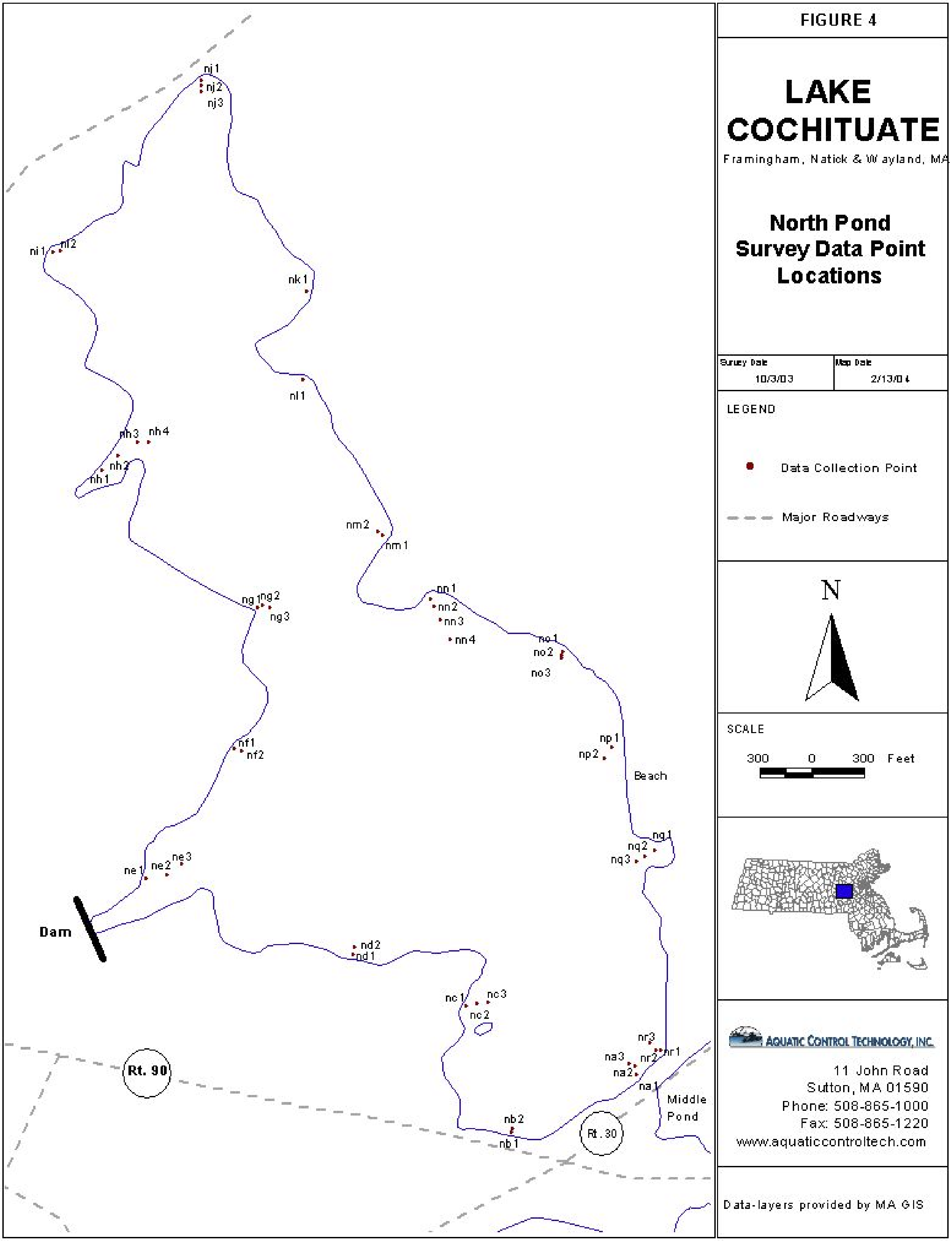
FIGURE 4
LAKE COCHITUATE
Framingham, Natick & Wayland, MA
North Pond Survey Data Point Locations
Survey Date
10/3/03
Map Date
2/13/04
LEGEND
Data Collection Point
Major Roadways
N
SCALE
300 0 300 Feet
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nj1
nj2
nj3
ni1
ni2
nk1
nl1
nh3
nh4
nh2
nh1
nm2
nm1
ng1
ng2
ng3
nn1
nn2
nn3
nn4
no1
no2
no3
nf1
nf2
np1
np2
Beach
nq1
nq2
nq3
ne1
ne2
ne3
Dam
nd2
nd1
nc1
nc3
nc2
nr3
nr1
nr2
na3
na2
na1
Middle Pond
nb2
nb1
Rt. 90
Rt. 30

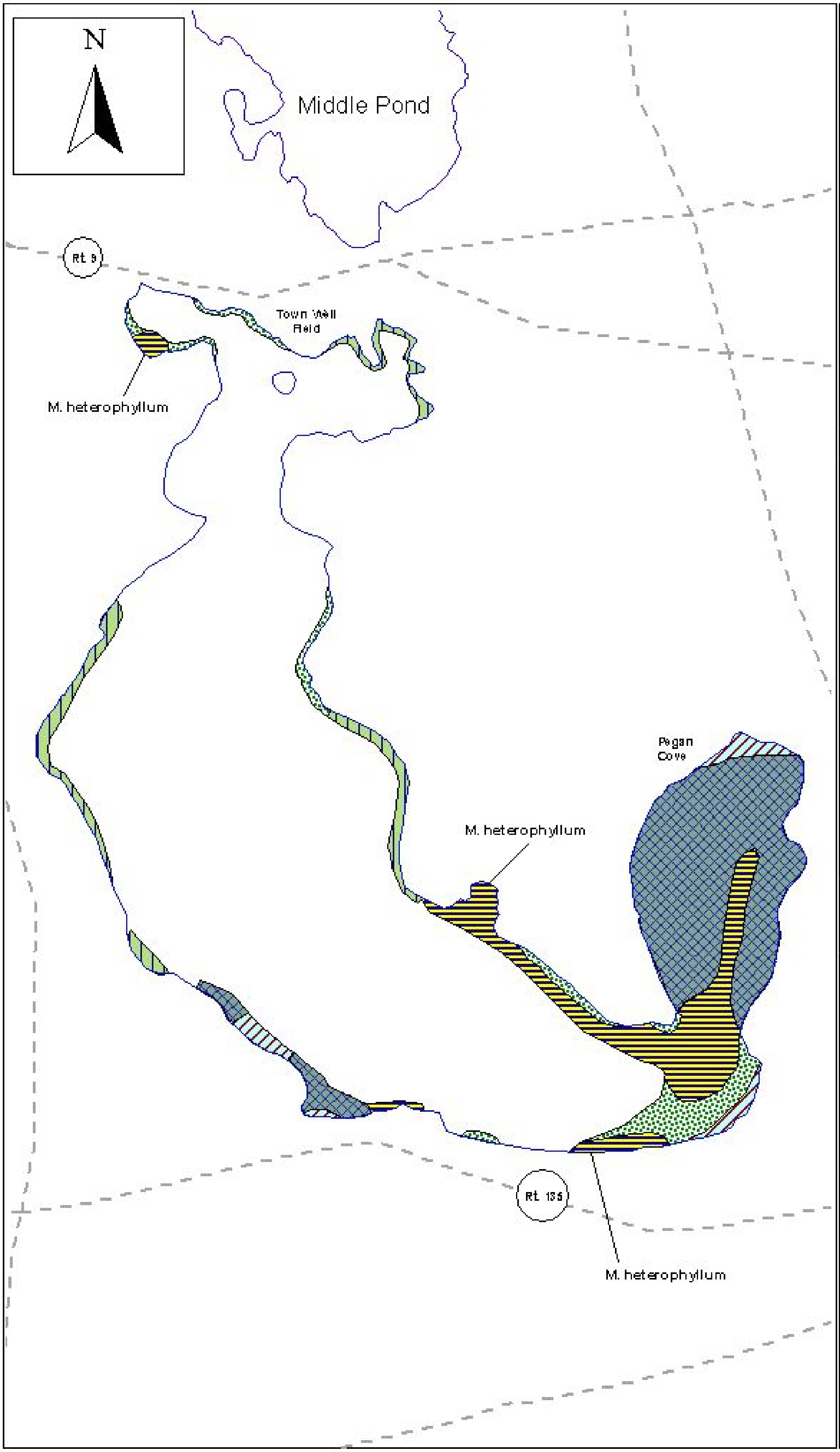

FIGURE 5

LAKE COCHITUATE

Framingham, Natick & Wayland, MA

South Pond Milfoil Distribution

Survey Date	Map Date
6/12/03 & 10/3/03	2/13/04

LEGEND

- Milfoil Cover <10%
- Milfoil Cover 10-25%
- Milfoil Cover 25-50%
- Milfoil Cover 50-75%
- Milfoil Cover >75%

SCALE

500 0 500 Feet

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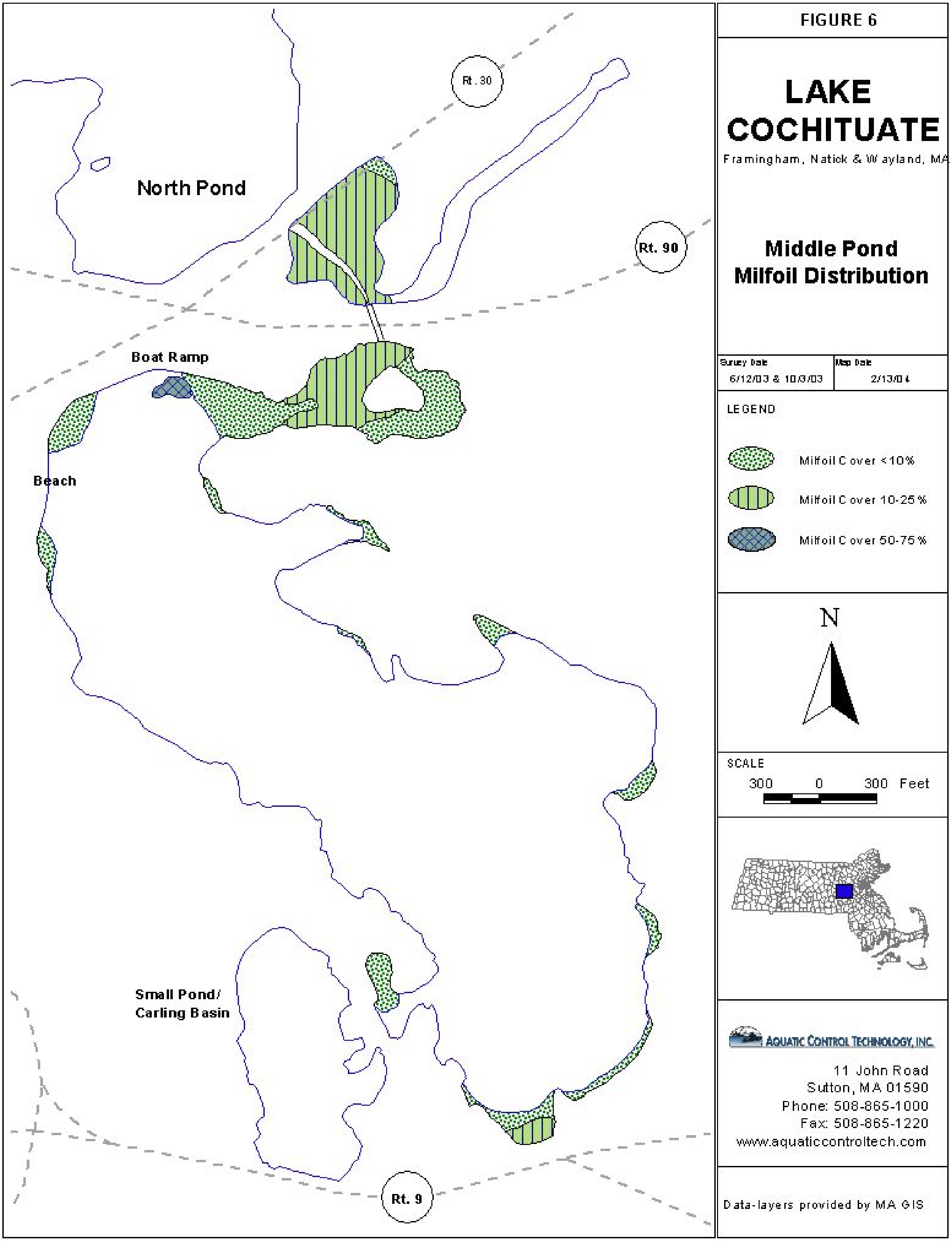
Rt. 30
North Pond
Rt. 90
Boat Ramp
Beach
Small Pond/
Carling Basin
Rt. 9
FIGURE 6
LAKE
COCHITUATE
Framingham, Natick & Wayland, MA
Middle Pond
Milfoil Distribution
Survey Date
6/12/03 & 10/3/03
Map Date
2/13/04
LEGEND
Milfoil Cover <10%
Milfoil Cover 10-25%
Milfoil Cover 50-75%
N
SCALE
300 0 300 Feet
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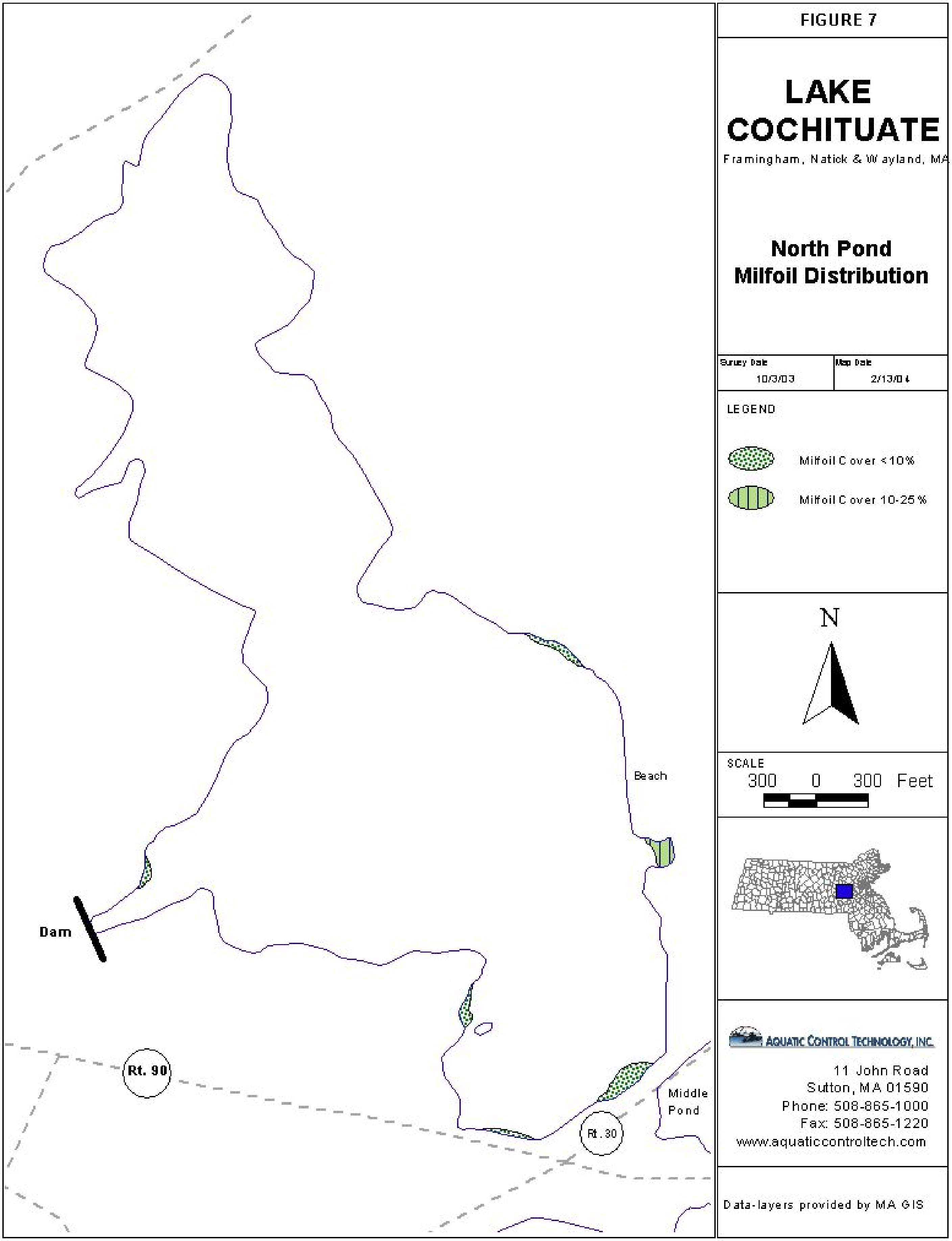
FIGURE 7
LAKE COCHITUATE
Framingham, Natick & Wayland, MA
North Pond
Milfoil Distribution
Survey Date
10/3/03
Map Date
2/13/04
LEGEND
Milfoil Cover <10%
Milfoil Cover 10-25%
N
SCALE
300 0 300 Feet
Aquatic Control Technology, Inc.
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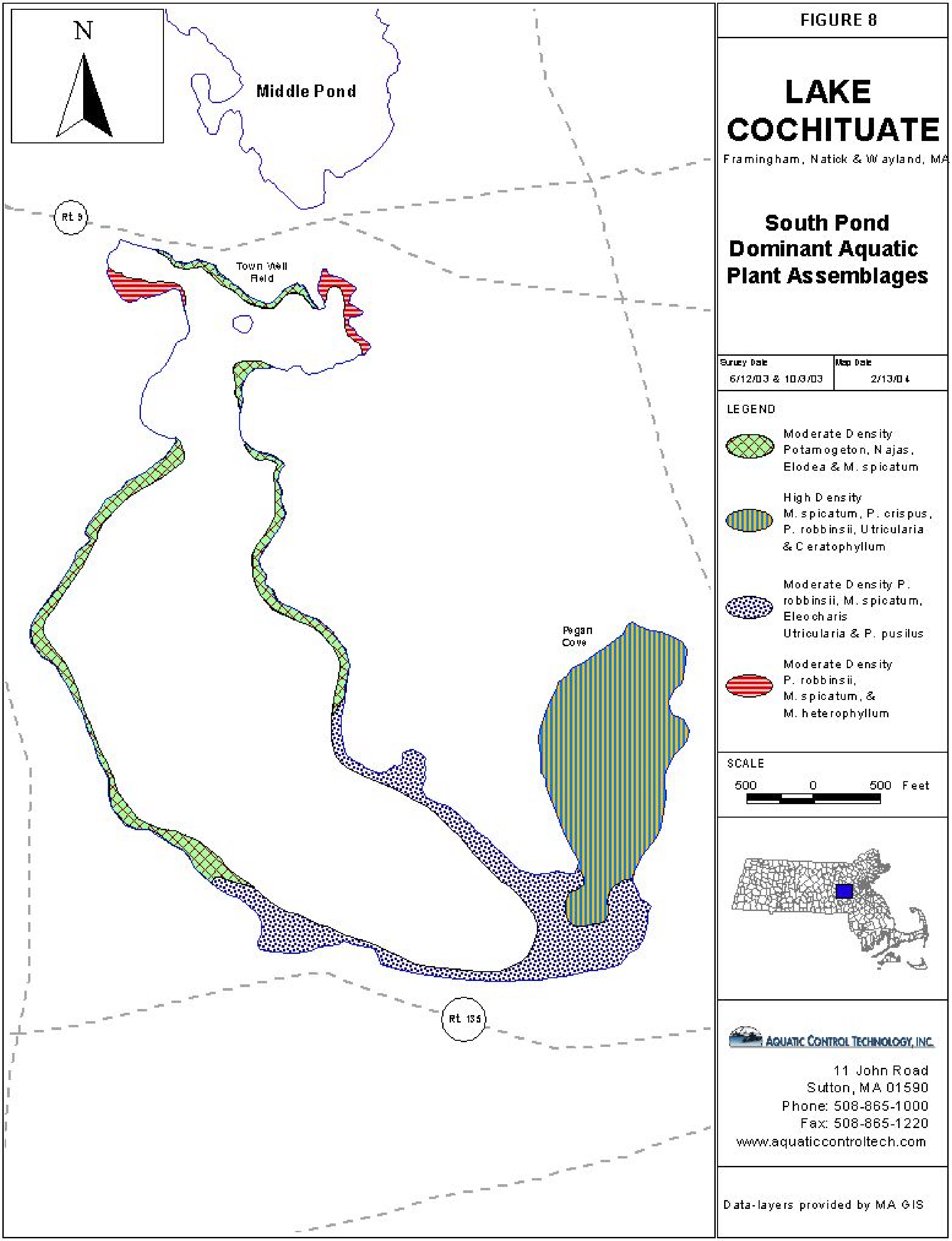
Data-layers provided by MA GIS
Beach
Dam
Rt. 90
Rt. 30
Middle
Pond


N
Middle Pond
Rt 9
Town Well Field
Pegan Cove
Rt 135
FIGURE 8
LAKE COCHITUATE
Framingham, Natick & Wayland, MA
South Pond Dominant Aquatic Plant Assemblages
Survey Date 6/12/03 & 10/3/03
Map Date 2/13/04
LEGEND
Moderate Density Potamogeton, Najas, Elodea & M. spicatum
High Density M. spicatum, P. crispus, P. robbinsii, Utricularia & Ceratophyllum
Moderate Density P. robbinsii, M. spicatum, Eleocharis Utricularia & P. pusilus
Moderate Density P. robbinsii, M. spicatum, & M. heterophyllum
SCALE
500 0 500 Feet
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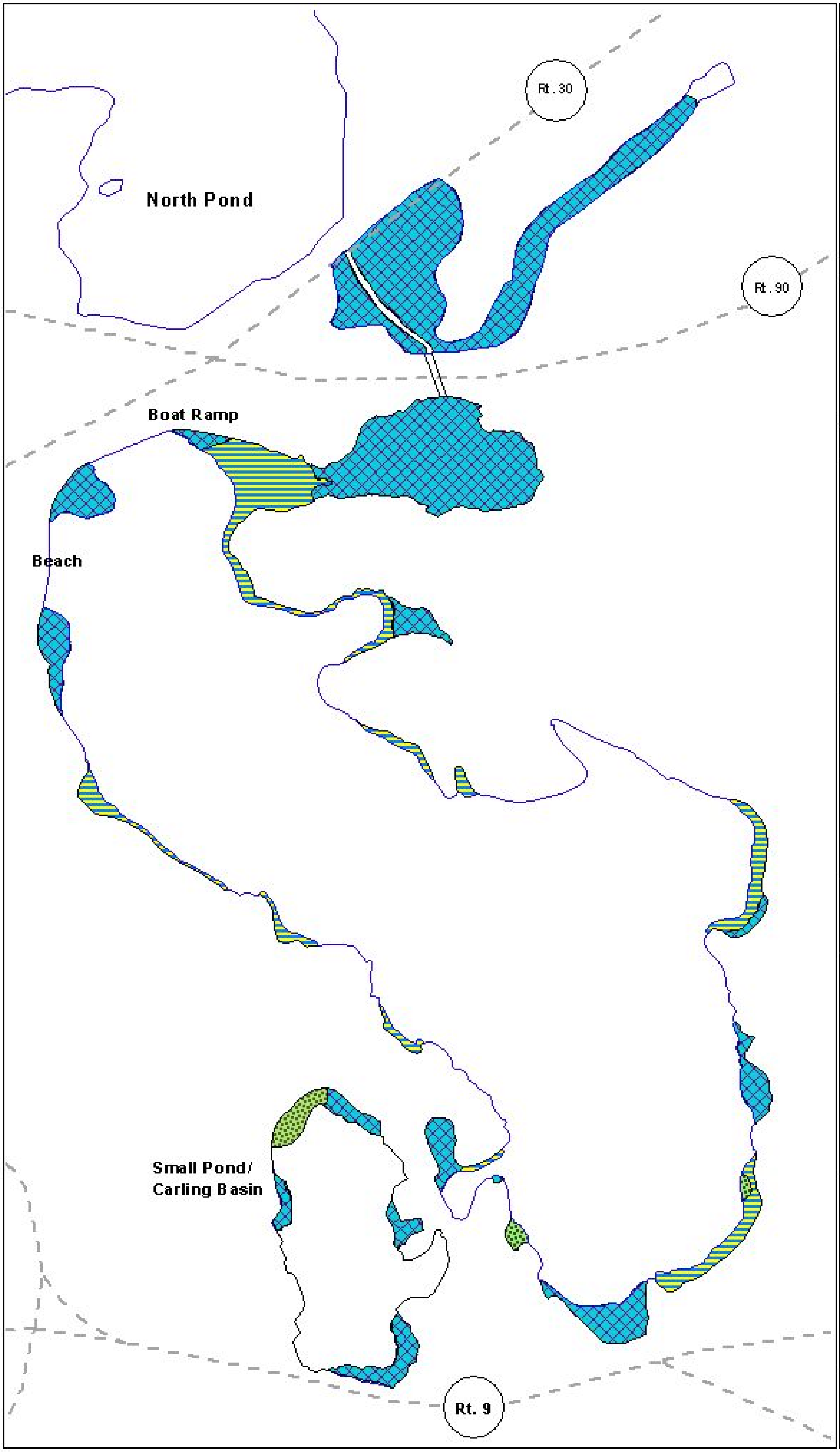


FIGURE 9

LAKE COCHITUATE

Framingham, Natick & Wayland, MA

Middle & Small Ponds Dominant Aquatic Plant Assemblages

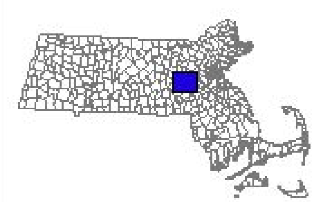
Survey Date	Map Date
6/12/03 & 10/3/03	2/13/04

LEGEND

- Moderate Density Potamogeton robbinsii, Ceratophyllum & M. spicatum
- Low Density Potamogeton, Najas, & Vallisneria,
- Nymphaea

N

SCALE
300 0 300 Feet



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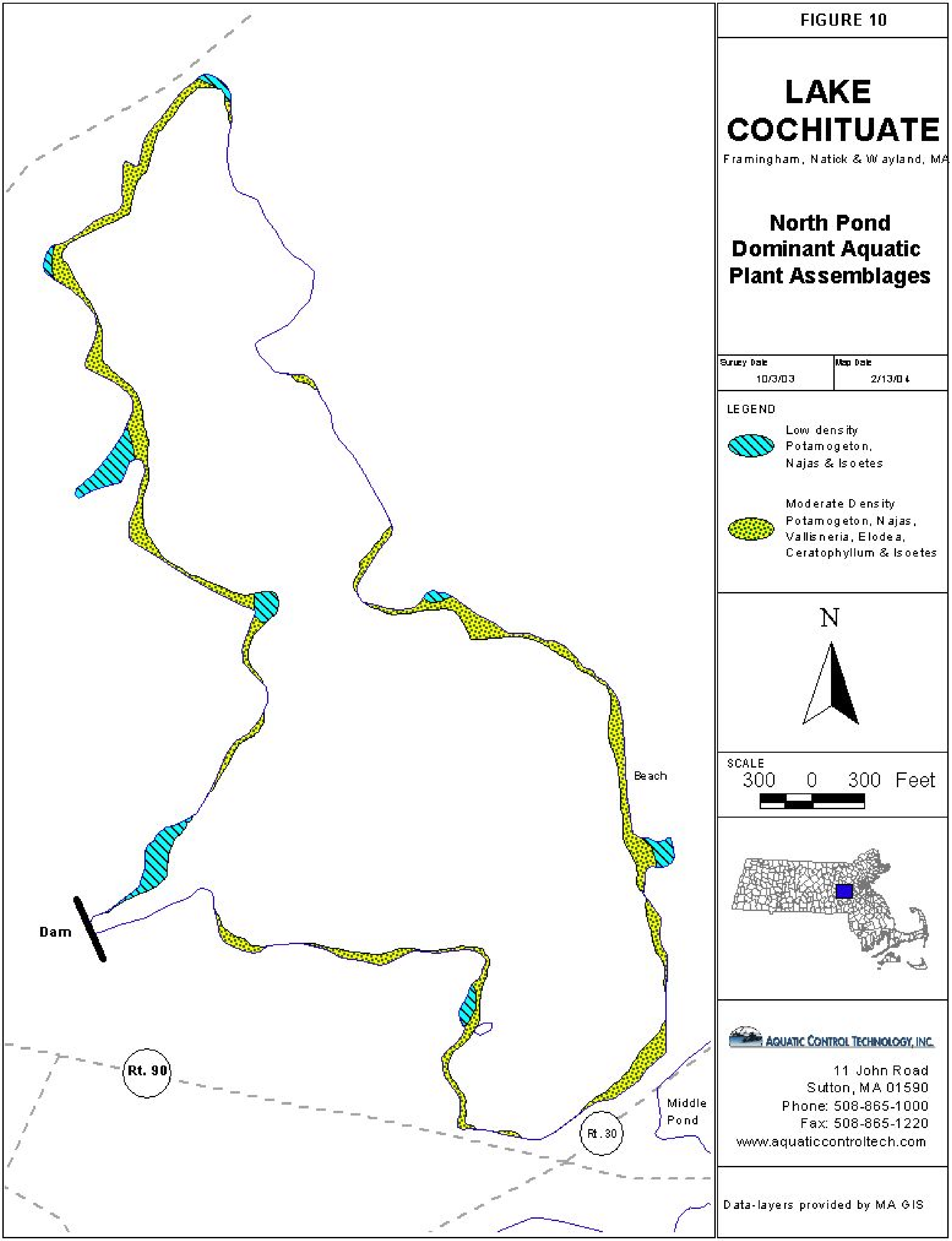
FIGURE 10
LAKE COCHITUATE
Framingham, Natick & Wayland, MA
North Pond Dominant Aquatic Plant Assemblages
Survey Date 10/3/03
Map Date 2/13/04
LEGEND
Low density Potamogeton, Najas & Isoetes
Moderate Density Potamogeton, Najas, Vallisneria, Elodea, Ceratophyllum & Isoetes
N
SCALE
300 0 300 Feet
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Data-layers provided by MA GIS
Beach
Dam
Rt. 90
Rt. 30
Middle Pond

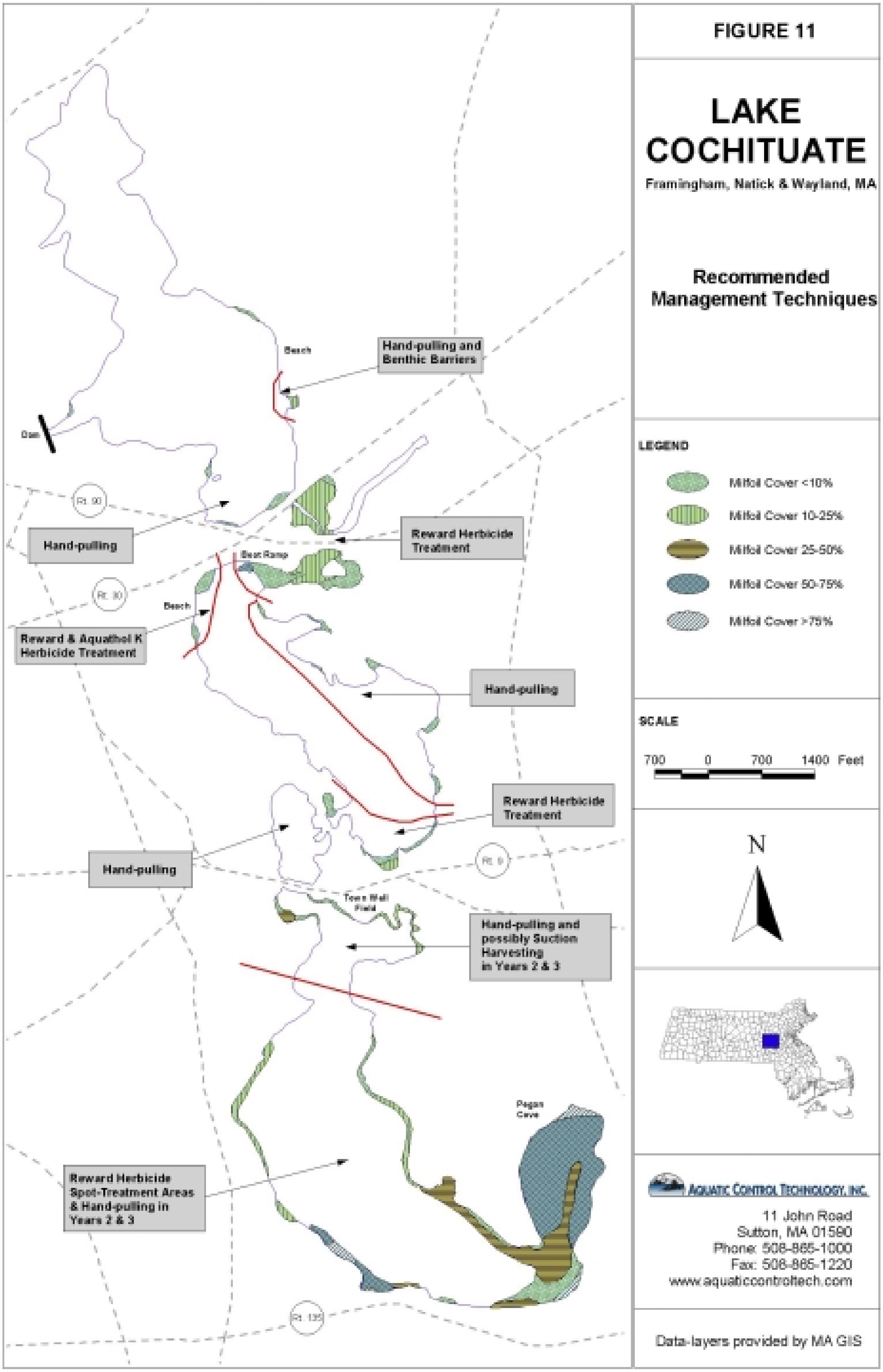
FIGURE 11
LAKE COCHITUATE
Framingham, Natick & Wayland, MA
Recommended Management Techniques
Hand-pulling and Benthic Barriers
Beach
Dam
Rt. 30
Hand-pulling
Reward Herbicide Treatment
Boat Ramp
Beach
Reward & Aquathol K Herbicide Treatment
Hand-pulling
Reward Herbicide Treatment
Hand-pulling
Rt. 9
Town Well Field
Hand-pulling and possibly Suction Harvesting in Years 2 & 3
Pegan Cove
Reward Herbicide Spot-Treatment Areas & Hand-pulling in Years 2 & 3
Rt. 135
LEGEND
Milfoil Cover <10%
Milfoil Cover 10-25%
Milfoil Cover 25-50%
Milfoil Cover 50-75%
Milfoil Cover >75%
SCALE
700 0 700 1400 Feet
N
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Appendix B

Tables of Transect/Data Point Field Data

SOUTH POND – 2003 Transect / Data Point Survey Data **Survey Date 6/12/03**

Transect & Data Point	Water Depth	Sediment Type	Dominant Vegetation	% Plant Cover	% Milfoil Cover	Biomass Index
S1a	3	M	Mh, Ms, U	30	70	3
S1b	9.5	M	Mh, U	25	80	2
S1c	11.5	M				
S2a	7.5	M/S				
S3a	4.5	S	Pp, Pt, Pr	30		2
S3b	9.5	S	U, Pr	20		1
S4a	3	S/M	Pr, Pp, U	80		2
S4b	10	S	Ec, Nf, U, Ni	50		1
S4c	14					
S5a	3.5	S	Pp, Ms	50	25	2
S5b	7.5		Pr	25		1
S5c	11					
S6a	3		Pp, U, Ms	70	15	3
S6b	9.5					
S7a	3		Pr, Ec, Ms	90	15	3
S7b	9		Pr, Ni	10		1
S8a	6.5		Pp (rich)	30		3
S9a	7.5		Pr, Ms	40	50	3
S10a	9		Ms	50	100	3
S11a	3	S	Pp, U, Ms	50		2
S11b	7		Pr, Ms	60	50	3
S11c	9.5					
S12a	7		Pc, Pt, Ms	70	20	3
S13a	4		Ms	10	100	2
S13b	5		Pr, Ec, Ms	70	30	2
S13c	6.5		Pr, Ms, Ec	80	50	3
S13d	8		Pr	10		1
S13e	9					
S14a	9		Pr, U, Mh	50	10	2
S15a	6	S	Ec, Pr, Ms	70	30	2
S16a	4		Ms, Pp, U, Mh, Pc	80	60	3
S16b	6		Ec, Pr, Ms	60	10	2
S16c	6		U, Ms	90	30	3
S16d	6		U, Ms	90	30	3
S16e	4.5		U, Pp, Ms	70	10	3
S17a	8		Ms, U, Pc	100	60	3
S17b	8.5		Ms, Pc	70	80	3
S17c	8		Ms, Pc, U	80	70	3
S17d	8.5		U, Ms, Pc	80	10	3
S17e	3.5		Ms, U, Pr	80	60	4
S18a	5.5		Ms, Pr, U	100	70	4
S18b	8		U, Pr, Ms	70	30	3
S18c	7.5		Ms, U, Pc, Fa	80	50	3
S18d	8		Ms, U	100	60	4

Transect & Data Point	Water Depth	Sediment Type	Dominant Vegetation	% Plant Cover	% Milfoil Cover	Biomass Index
S18e	8		Ms, Pr, Pc	90	70	4
S19a	8		Ms, Pr, U	80	50	3
S19b	8		Ms, Ni	70	60	3
S19c	8.5		Ms, U	90	50	3
S19d	7.5		Ms, Ec, Pr	80	50	3
S20a	8		Ms, Pc, Cd	100	90	4
S21a	2		Pp, Ms	30	25	2
S21b	7		Pt, Ec, Ms, U	70	25	2
S21c	10.5					
S22a	5.5		Mh, Pr, Ec, Ms	80	40	3
S22b	6.5		Ec, Pr, Mh, Ms	90	30	3
S22c	7.5		Ms, U, Pr, Mh	100	60	3
S22d	12					
S23a	3		Pp, Pt, Ec	60		2
S23b	9		Nf, U, Ms	50	20	2
S24a	5.5		Mf, Pr, Ms	70	15	3
S24b	10		Nf	20		1
S25a	4		Nf, Pr, Ec	60		2
S26a	3		Pp	50		2
S26b	9		Nf, Pr	40		1
S26c	12		Nf	20		1
S27a	8					
S28a	10.5		Pr, Ms	50	20	2
S29a	7.5		Nf, Ec, Ms	30	10	2
S30a	3.5					
S30b	9		Nf, Ec	20		1
Averages	*7.2*			*60.5*	*44.0*	*2.5*

MIDDLE POND – 2003 Transect / Data Point Survey Data Survey Date 10/3/03

Transect & Data Point	Water Depth	Sediment Type	Dominant Vegetation	% Plant Cover	% Milfoil Cover	Biomass Index
M1a	5	M	Pr, Cd, Ms (Fa, Wo)	100	10	3
M1b	2.5	M/S	Pr, Cd, Ms, Fa	80	15	3
M1c	5	M	Pr, Cd, Ms, Fa	100	15	3
M1d	5	M	Pr, Cd, Ms, Fa	100	15	3
M2a	1	M	Wo, Nu, Pl, Nf	100		3
M2b	4.5	M	Pr, Cd, No	70		2
M2c	4.5	M	Pr, Cd, Fa	70		2
M2d	4	M	Cd, Pr, Pa, Ms	70	10	2
M3a	3	M	Pr, Ms, Ph	100	25	3
M3b	5.5	M	Pr, Fa, Cd	100		2
M3c	6.5	M	Pr, Cd, Fa	80		2
M3d	6.5	M	Pr, Cd, Fa, Ms	100	10	3
M4a	4	M	Ms, Pr, Cd	100	50	3
M4b	7	M	Pr, Ms	70	25	3
M4c	6	M	Pr, Ms (No)	90	25	3
M5a	4	M	Pr, Ph, Ms, V	80	10	2
M5b	7	M	Pr, Ms	80	10	2
M5c	7		Pr, Nf, Pg, Ms	80	5	2
M6a	4	S	Pg, V, Ms	70	5	2
M6c	10	S/G	Nf	10		1
M7a	2.5	S	V, Ph, Pr, Ms	70	5	2
M7b	8	M	Pr	80		2
M7c	10		Nf, Pr, Fa	30		1
M8a	2.5	S/G	V, Nf, Pr, Ms	60	5	2
M8b	4.5		V, Ph, Pr, Nf, Ms	60	5	2
M8c	10		Pr	30		1
M9a	3.5	S/G	Pr	10		1
M10a	3.5	S/G	V, Ph, Ms	80	15	2
M10b	8		Pr, Ms	60	5	2
M10c	12					
M11a	2.5	S	V, Ph, I, Ms	90	5	2
M11b	6		Pr	80		2
M12a	3	S	V, Ms	40	5	1
M13a	4.5	S/LL	Ms, Pr, Cd	20	100	2
M13b	10		Pr, Ms	30	50	2
M13c	13		Ms	10	100	1
M14a	6	M	Pr, Fa, Mh (Ny)	80	5	2
M14b	6	M	Pr, Vv, Mh, Ms	100	5	2
M15a	3	S	Cd, I, Ms, Pr	20	10	1
M15b	8	R				
M16a	5	S	Pr, Pg	30		1
M17a	3	S/M	V, Pg, Pr, Ms	80	5	2
M17b	8		Pr, Ms	30	10	2
M18a	3	S	Pr, Ms	60	5	2
M18b	8		Pr, Ms	80	10	2
M18c	12		Pr, Ms	60	5	2
Averages	*5.8*			*66.8*	*18.1*	*2.0*

MIDDLE POND – 2003 Transect / Data Point Survey Data **Survey Date 10/3/03**

Transect & Data Point	Water Depth	Sediment Type	Dominant Vegetation	% Plant Cover	% Milfoil Cover	Biomass Index
Na1	3	S/G	Pg, Cd, Ms	50	10	3
Na2	6	S	Pr, Ms	50	10	2
Na3	12		Pr	10		1
Nb1	6	R	Pg, Pa (Ms 1 plant)	20	5	2
Nb2	14					
Nc1	4	S/G	Pr, Pg, Ms	70	5	3
Nc2	9	R	Pg	30		1
Nc3	13					
Nd1	3	R	Pg	40		2
Nd2	10	R				
Ne1	2	S	Pg, Pr, V, I , Ms (Pl)	80	5	2
Ne2	7		Pr	70		1
Ne3	13					
Nf1	4		Nf, Pm			
Nf2	10					
Ng1	2		Eo, Pm, Pg	70		2
Ng2	7		Pg	90		3
Ng3	12					
Nh1	6.5		Pr	80		2
Nh2	7		Pr	80		2
Nh3	7		Pg	50		2
Nh4	10		Fa	30		1
Ni1	3	S	Pg, Pr	40		2
Ni2	10		Pr	15		1
Nj1	3	M	Pr, Pg, I	70		2
Nj2	3.5		Pr	50		
Nj3	12			.		
Nk1	6		leaf litter, branches			
Nl1	4	G	I	10		1
Nm1	2	S/G	Pg	40		2
Nm2	7	G				
Nn1	3	M	I, Pq, U	70		1
Nn2	5.5	M	leaf litter			
Nn3	7.5	G	Fa			
Nn4	12					
No1	3		Pg, V, Pm, Ms, Nf	70	5	3
No2	7		Pm, V, Nf	40		1
No3	12		Fa			
Np1	6		Pr	80		1
Np2	10					
Nq1	3	M	Pr, Ms	70	15	2
Nq2	5		Pr, Pg	70		2
Nq3	11		Fa			
Nr1	3		Pg	30		2
Nr2	5		Pg	50		2
Nr3	9		Nf	30		1
Averages	*7.0*			*51.8*	*7.9*	*1.8*